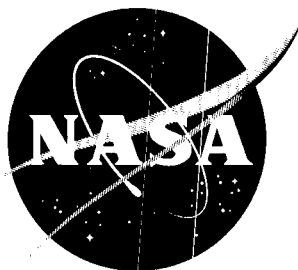


CONFIDENTIAL

Copy

NASA TM X-433



N68 18038

# TECHNICAL MEMORANDUM

X-433

STATIC LONGITUDINAL CHARACTERISTICS OF  
SEVERAL PROJECT MERCURY LAUNCH VEHICLES AT MACH NUMBERS  
BETWEEN 0.4 AND 6.8

By James D. Church, Albin O. Pearson  
and Peter T. Bernot

Langley Research Center  
Langley Field, Va.

CLASSIFICATION CHANGED TO DECLASSI-  
FIED EFFECTIVE JUNE 12, 1963  
AUTHORITY NASA 4 BY J. J. CARROLL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON

February 1961

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

---

TECHNICAL MEMORANDUM X-433

---

STATIC LONGITUDINAL CHARACTERISTICS OF  
SEVERAL PROJECT MERCURY LAUNCH VEHICLES AT MACH NUMBERS

BETWEEN 0.4 AND 6.8\*

By James D. Church, Albin O. Pearson,  
and Peter T. Bernot

SUMMARY

18038

An investigation has been conducted in various wind tunnels at the Langley Research Center to determine the static longitudinal stability characteristics of some Project Mercury booster-capsule configurations. Data were obtained for models of the Little Joe, Redstone-Mercury, and Jupiter-Mercury configurations with the various capsule arrangements suitable to these particular vehicles over a Mach number range of 0.4 to 6.8 and a maximum angle-of-attack range from approximately  $-14^{\circ}$  to  $18^{\circ}$ . Brief comments on the significance of the model stability data with respect to proposed full-scale flight are presented.

INTRODUCTION

Numerous investigations of the suitability of a Project Mercury capsule as a part of the man-in-space program are being conducted by the National Aeronautics and Space Administration. (See, for example, refs. 1 to 3.) In this connection, the NASA will evaluate the operational concepts, and test some of the actual hardware of this project through the use of various full-scale booster-capsule configurations launched into suborbital trajectories. These flights will be conducted in several stages, that is, simulation of increasingly larger portions of the final exit and reentry trajectories will be attempted as the program advances. Accordingly, tests were conducted in various wind tunnels to determine the static aerodynamic characteristics of various possible launch configurations. The three configurations reported herein are identified as the Little Joe, Redstone-Mercury, and Jupiter-Mercury vehicles.

---

\*Title, Unclassified.

CONFIDENTIAL

0317120A1030

CONFIDENTIAL

Evaluation of the stability results requires a knowledge of certain operational features of the various vehicles. For example, the Little Joe configuration incorporates large fins mounted on a canister enclosing a solid-propellant rocket cluster and relies entirely on aerodynamic forces for stability. Both of the other two vehicles employ liquid propellants and either augment stability with jet vanes (Redstone-Mercury) or rely exclusively on gimballed rockets for stability (Jupiter-Mercury).

Data for the present tests were obtained over a Mach number range of 0.4 to 6.8 in the Langley 8-foot transonic pressure tunnel, the Langley Unitary Plan wind tunnel (4-foot test section), and the Langley 11-inch hypersonic tunnel. The maximum angle-of-attack range of the investigation was from approximately  $-14^{\circ}$  to  $18^{\circ}$ . The significance of the stability results of the various configurations in view of the full-scale requirements is briefly discussed.

#### SYMBOLS

The basic data are presented as force and moment coefficients referred to the body-axes system shown in figure 1.

- A            maximum cross-sectional area of booster body,  $\frac{\pi d^2}{4}$ , sq ft
- $C_A$            axial-force coefficient,  $\frac{\text{Total axial force}}{qA} - C_{A,b}$
- $C_{A,b}$           base axial-force coefficient,  $\frac{\text{Base axial force}}{qA}$
- $C_m$            pitching-moment coefficient,  $\frac{\text{Pitching moment}}{qAd}$
- $C_{m_{\alpha}}$         pitching-moment curve slope,  $\frac{\partial C_m}{\partial \alpha}$ , per deg
- $C_N$            normal-force coefficient,  $\frac{\text{Normal force}}{qA}$ , per deg
- $C_{N_{\alpha}}$         normal-force curve slope,  $\frac{\partial C_N}{\partial \alpha}$ , per deg
- d            maximum diameter of booster body, in.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

3

M	free-stream Mach number
$P_t$	free-stream stagnation pressure, lb/sq ft
q	free-stream dynamic pressure, lb/sq ft
R	Reynolds number based on d
$T_t$	free-stream stagnation temperature, °F
X,Y,Z	orthogonal set of body axes
x	longitudinal distance forward of booster base measured along body center line, in.
x/d	longitudinal distance forward of booster base in diameters
$\Delta(x/d)$	effective static margin, distance in diameters that the center of gravity is ahead of the center of pressure, $(x/d)_{cg} - (x/d)_{cp}$
$\alpha$	angle of attack referred to body center line, deg
$\beta$	angle of sideslip referred to body center line, deg
Subscripts:	
cg	center of gravity
cp	center of pressure

## APPARATUS AND DATA

### Wind Tunnels

The investigations were conducted in the Langley 8-foot transonic pressure tunnel (8-foot TPT) at Mach numbers from about 0.40 to 1.20, in the Langley Unitary Plan wind tunnel (4-foot UPWT) at Mach numbers from near 1.70 to 4.65, and in the Langley 11-inch hypersonic tunnel (11-inch HT) at Mach numbers near 6.8.

The 8-foot TPT facility is of the variable-pressure, continuous-flow type and has a slotted test section in which the Mach number can

CONFIDENTIAL

0317120A1030

be varied continuously up to a Mach number of 1.20. Essentially, all data presented from this tunnel are free of wall-reflected disturbances.

The supersonic tests were conducted in both the low and high Mach number test sections of the 4-foot UPWT, which is a variable-pressure, continuous-flow tunnel. The nozzles leading to the test sections are of the asymmetric sliding-block type, which permit a continuous variation in test-section Mach number from approximately 1.5 to 2.9 in the low Mach number test section and from about 2.3 to 4.7 in the high Mach number test section. The dewpoint was controlled in the 8-foot TPT and 4-foot UPWT to maintain an airflow which is free of condensation shocks.

The hypersonic tests were performed in the 11-inch HT. This facility is of the intermittent-operation type and utilizes both a high-pressure tank and a vacuum tank. The tunnel is equipped with a two-dimensional, single-step nozzle which will produce a nominal Mach number of 6.8 at varying stagnation pressures of 5 atmospheres to 37 atmospheres. To avoid liquefaction, a stagnation temperature of about 650° F is maintained for all tests.

### Models

Details of the full-scale vehicles are given in figure 2 and photographs of the various wind-tunnel models are shown in figure 3. All of the models were hollow, metal bodies of revolution. The scale sizes of the various models are given in the following table:

Tunnel	Scale sizes for -		
	Little Joe	Redstone-Mercury	Jupiter-Mercury
8-foot TPT	0.0750	0.04645	-----
4-foot UPWT	.0750	.04645	0.04645
11-inch HT	.01875	-----	.01714

Small differences existed between the wind-tunnel models and full-scale vehicles, particularly for the Little Joe configuration. For this configuration the 8-foot TPT and 11-inch HT models had 8.3 inches (full scale) removed from the base, as indicated by the dashed line at station 521.1 in figure 2(a). The 8-foot TPT model had a Marman clamp simulated at the juncture of the capsule and booster (fig. 3(a)) and four rocket fairings mounted on the parachute canister. The 4-foot UPWT model also had the Marman clamp attached (fig. 3(a)) and in addition had two small simulated camera pods, spaced 180° apart, on the

DECLASSIFIED

CONFIDENTIAL

5

capsule and two probes mounted on the nose. The Little Joe models were tested with and without the escape rocket and tower attached (escape and exit configurations).

The Redstone-Mercury model with the escape tower was the same for the 8-foot TPT and 4-foot UPWT tests and differed from the full-size vehicle only in the addition of four small steering rocket fairings on the capsule (fig. 3(c)). The Jupiter-Mercury models without the escape tower were tested in the 4-foot UPWT and 11-inch HT (fig. 3(d)) and were similar to the full-scale vehicle (fig. 2(c)) except that the 11-inch HT model was tested without the stub pylon fairing.

### Tests

All the models were sting supported; normal-force, axial-force, and pitching-moment characteristics were determined by means of an internal electrical strain-gage balance. The conditions at which the tests were performed in the various facilities are listed in table I. The base pressures were obtained from a single static-pressure orifice located near the bases of the models. Schlieren photographs were taken at the higher Mach numbers.

### Corrections and Accuracy

Angles of attack have been corrected for both tunnel flow angularity and deflection of strain-gage balance and sting support due to aerodynamic loads. Axial-force coefficients have been corrected to a condition of free-stream static pressure at the base of all models.

Based upon calibration and repeatability of data it is estimated that the various measured quantities are accurate within the following limits:

Measured quantities	8-foot TPT		4-foot UPWT		11-inch HT
$\alpha$ , deg . . . . .	$\pm 0.2$		$\pm 0.2$		$\pm 0.1$
M . . . . .	$\pm 0.005$		$\pm 0.02$		$\pm 0.01$
Little Joe:	M = 0.6	M = 1.2	M = 1.81	M = 4.65	M = 6.8
$C_N$ . . . . .	$\pm 0.30$	$\pm 0.070$	$\pm 0.038$	$\pm 0.018$	$\pm 0.014$
$C_A$ . . . . .	$\pm 0.06$	$\pm 0.015$	$\pm 0.013$	$\pm 0.008$	$\pm 0.004$
$C_m$ . . . . .	$\pm 0.06$	$\pm 0.014$	$\pm 0.018$	$\pm 0.010$	$\pm 0.013$
Redstone-Mercury:					
$C_N$ . . . . .	$\pm 0.047$	$\pm 0.022$	$\pm 0.028$		
$C_A$ . . . . .	$\pm 0.020$	$\pm 0.010$	$\pm 0.009$		
$C_m$ . . . . .	$\pm 0.029$	$\pm 0.014$	$\pm 0.025$		
Jupiter-Mercury:					
$C_N$ . . . . .			$\pm 0.017$		$\pm 0.022$
$C_A$ . . . . .			$\pm 0.005$		$\pm 0.007$
$C_m$ . . . . .			$\pm 0.039$		$\pm 0.012$

CONFIDENTIAL

# PRESENTATION OF RESULTS

The pitching-moment coefficients for the various models are referred to the moment-center locations shown in figure 2. The center-of-pressure and center-of-gravity locations are all referred to the bases of the models. For the Little Joe models with the reduced length the center-of-pressure locations are referred to the extended base utilized on the 4-foot UPWT model (full-scale station 529.4, fig. 2(a)).

The results are presented in the following figures:

	Figure
Typical schlieren photographs . . . . .	4
Variation of base axial-force coefficients with Mach number . . . . .	5
Aerodynamic characteristics of:	
Little Joe; escape . . . . .	6
Little Joe; exit . . . . .	7
Redstone-Mercury . . . . .	8
Jupiter-Mercury . . . . .	9
Summary of aerodynamic characteristics:	
Longitudinal; $\alpha \approx 0^\circ$ . . . . .	10
Effective static margins; $\alpha \approx 0^\circ$ . . . . .	11

# SUMMARY OF RESULTS

An investigation of the static longitudinal stability characteristics of some Project Mercury booster-capsule configurations has been conducted over a Mach number range of 0.4 to 6.8. The summary results are presented in figures 10 and 11; as the values of  $C_{m\alpha}$  for the Redstone-Mercury and Jupiter-Mercury have no direct significance, they are not shown in figure 10. A comparison of the various vehicles (fig. 10) indicates that lift and drag were increased, as would be expected, with the addition of booster fins and increases in fin area. In addition, the escape tower slightly decreased the  $C_{N\alpha}$  values of the Little Joe model from  $M = 1.0$  to 2.6; at higher speeds the effect was to increase  $C_{N\alpha}$ . However, the most significant results of the tests are indicated by the effective static margins,  $\Delta(x/d)$ , shown for each vehicle in figure 11, where the center-of-gravity positions illustrated represent the worst flight conditions anticipated; these results are discussed in the following paragraphs.

Little Joe: This is the only vehicle of the present investigation that relies entirely on aerodynamic forces for stability over its

DECLASSIFIED

CONFIDENTIAL

7

flight envelope. The data indicate that this vehicle is stable, as required, over the tested speed range and even though the stability decreases with increasing Mach number,  $\Delta(x/d)$  is at least 0.3 diameter at the highest speed contemplated ( $M \approx 5.8$ ).

Redstone-Mercury: The requirements of this test were to determine the speed at which the system becomes neutrally stable; as can be seen, this occurs at about  $M = 1.9$ . It is intended to ballast this vehicle (with the minimum additional weight possible) such that the system will be aerodynamically stable to about  $M = 2.5$  in the event of engine failure; with no malfunction, jet vanes provide the required stability over the entire booster trajectory.

Jupiter-Mercury: The purpose of this test was to determine the amount of aerodynamic instability present, since this system relies entirely on thrust vectoring for stability. A maximum value of  $\Delta(x/d) = -3$  diameters at  $M \approx 1.6$  is believed to be within the servo limits of the existing system (contained in unpublished Army Ballistic Missile Agency data).

Thus, the aerodynamic stability of each of the three vehicles appears to be within the capability of the respective operational systems.

Langley Research Center,  
National Aeronautics and Space Administration,  
Langley Field, Va., September 30, 1960.

#### REFERENCES

1. Pearson, Albin O.: Wind-Tunnel Investigation at Mach Numbers From 0.50 to 1.14 of the Static Aerodynamic Characteristics of a Model of a Project Mercury Capsule. NASA TM X-292, 1960.
2. Shaw, David S., and Turner, Kenneth L.: Wind-Tunnel Investigation of Static Aerodynamic Characteristics of a 1/9-Scale Model of a Project Mercury Capsule at Mach Numbers From 1.60 to 4.65. NASA TM X-291, 1960.
3. Pearson, Albin O.: Wind-Tunnel Investigation at Mach Numbers From 0.40 to 1.20 of the Static Aerodynamic and Control Characteristics of a Model of a Nonlifting Reentry Capsule in Combination With a Rocket Booster. NASA TM X-317, 1960.

CONFIDENTIAL

031710281030

8

CONFIDENTIAL

TABLE I.- TEST CONDITIONS

## (a) Little Joe

Facility	M	$\alpha$ , deg	$p_t$ , psf	$T_t$ , °F	q, psf	R
8-foot TPT	0.40	-6 to 12	2,120	125	210	$1.15 \times 10^6$
	.60	-6 to 12	2,120	125	418	1.57
	.80	-6 to 12	2,120	125	623	1.87
	.90	-6 to 12	2,120	125	710	1.97
	.95	-6 to 12	2,120	125	750	2.00
	.98	-6 to 12	2,120	125	770	2.03
	1.00	-6 to 12	2,120	125	783	2.04
	1.03	-6 to 12	2,120	125	801	2.04
	1.20	-6 to 12	2,120	125	881	2.08
4-foot UPWT	<sup>a</sup> 1.82	-3 to 14	996	125	389	.86
	<sup>b</sup> 2.10	-3 to 14	1,285	125	434	.98
	2.81	-9 to 14	2,575	150	516	1.29
	3.51	-14 to 14	5,375	150	599	1.85
	4.65	-14 to 14	13,830	175	601	2.59
11-inch HT	6.85	-2 to 12	51,500	650	475	.40

## (b) Redstone-Mercury

8-foot TPT	0.60	-10 to 12	1,880	125	372	$0.75 \times 10^6$
	.80	-10 to 12	1,880	125	553	.90
	.90	-10 to 12	1,880	125	631	.95
	.95	-10 to 12	1,880	125	665	.96
	.98	-10 to 12	1,880	125	683	.97
	1.00	-10 to 12	1,880	125	696	.98
	1.03	-10 to 12	1,880	125	712	.98
	1.20	-10 to 12	1,880	125	781	1.00
4-foot UPWT	1.70	-4 to 17	2,455	125	1,006	1.19
	2.10	-4 to 17	2,965	125	1,000	1.23
	2.51	-3 to 18	3,940	150	1,001	1.25
	2.87	-4 to 17	5,325	150	1,017	1.40

## (c) Jupiter-Mercury

4-foot UPWT	1.57	-4 to 14	2,355	125	1,000	$1.79 \times 10^6$
	2.10	-3 to 14	2,965	125	1,001	1.84
	2.51	-3 to 14	3,940	150	1,001	1.88
	2.87	-4 to 12	5,265	150	1,006	2.07
11-inch HT	6.71	-2 to 13	20,850	650	205	.19

<sup>a</sup>Exit only.

<sup>b</sup>Escape only.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

9

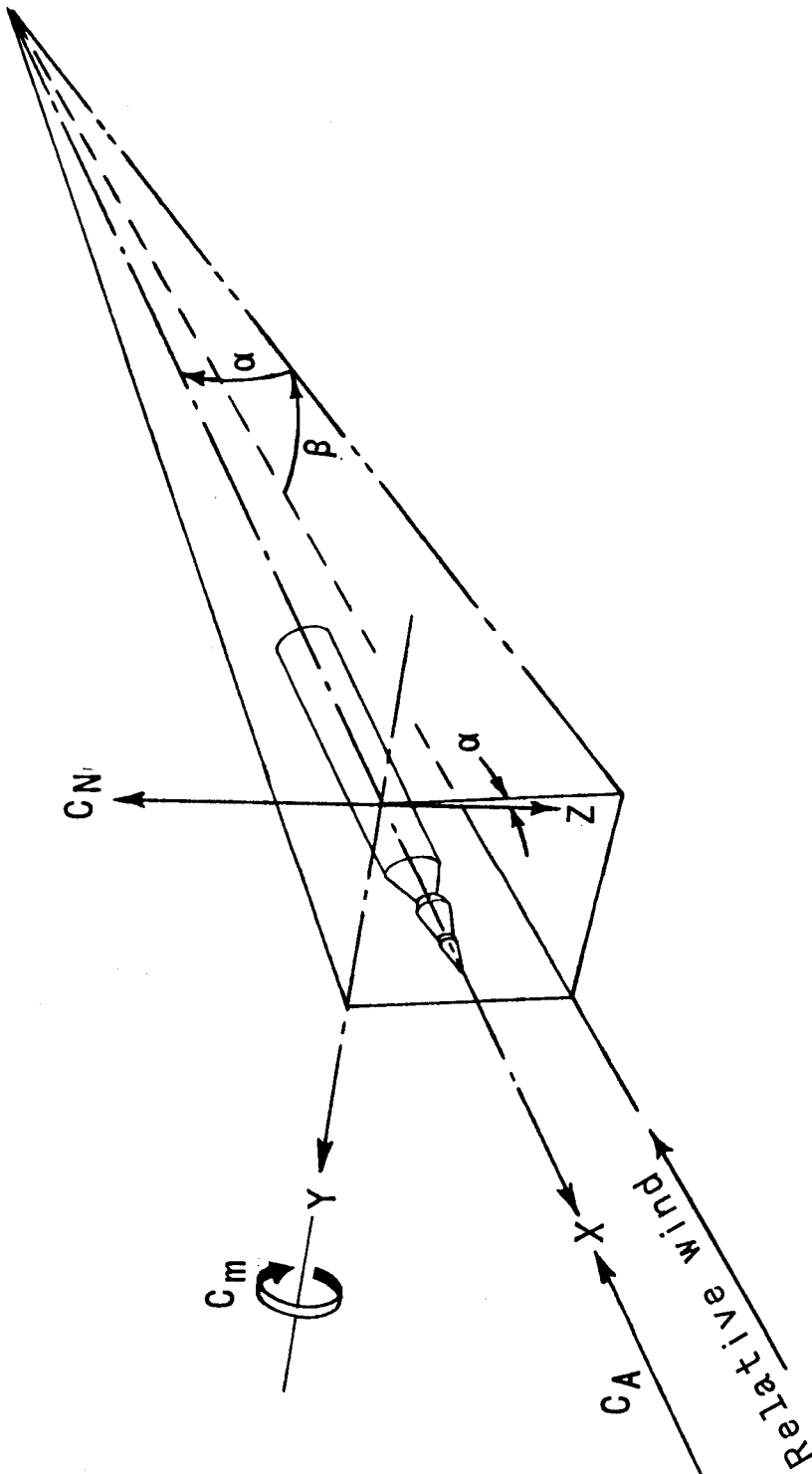
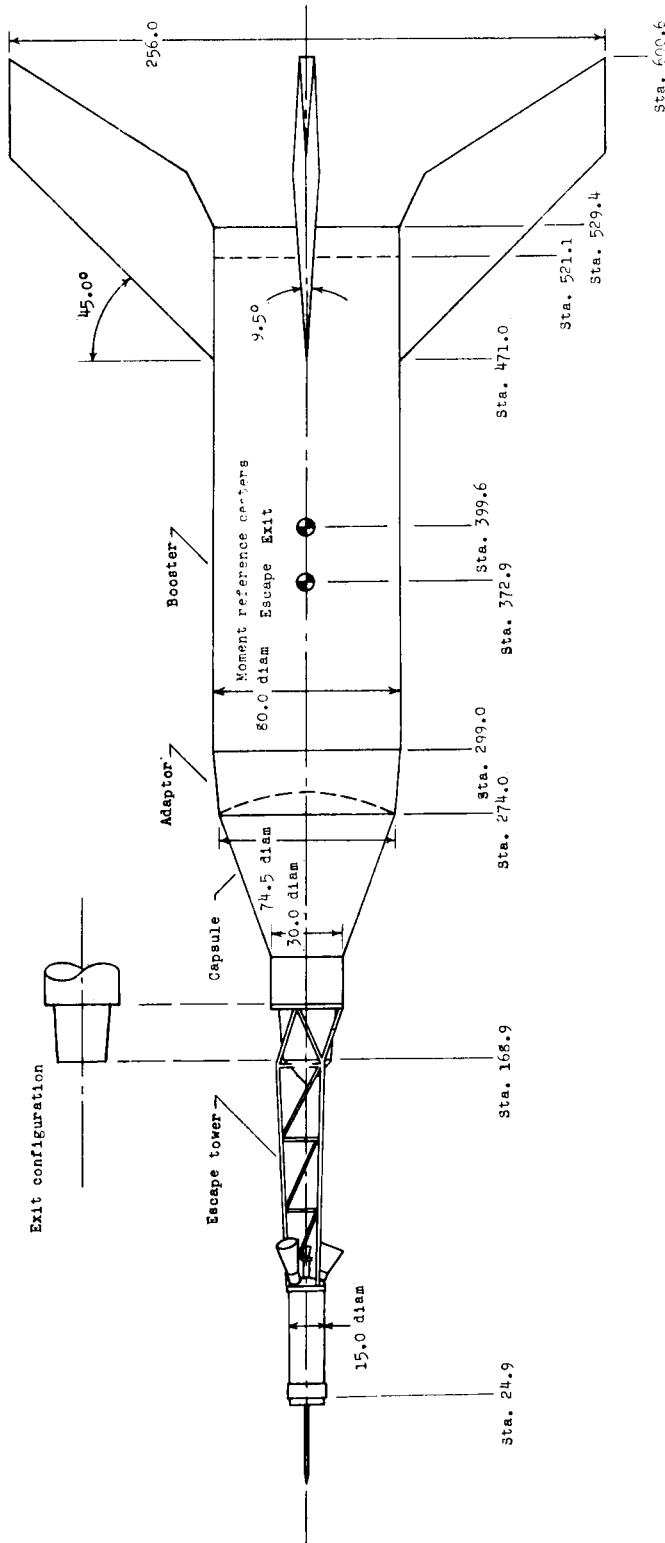


Figure 1.- Body system of axes. Arrows indicate directions of positive forces, moments, and angles.

CONFIDENTIAL

0379529 1030

CONFIDENTIAL



(a) Escape and exit configurations of Little Joe.

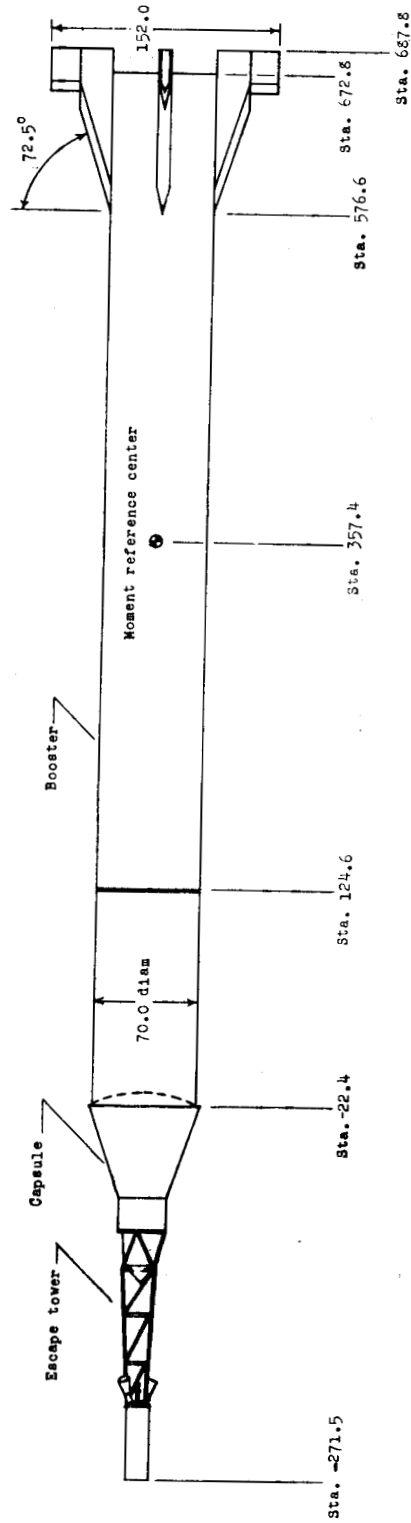
Figure 2.- General arrangement of various Project Mercury launch vehicles. All dimensions are in inches.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

11



(b) Redstone-Mercury configuration.

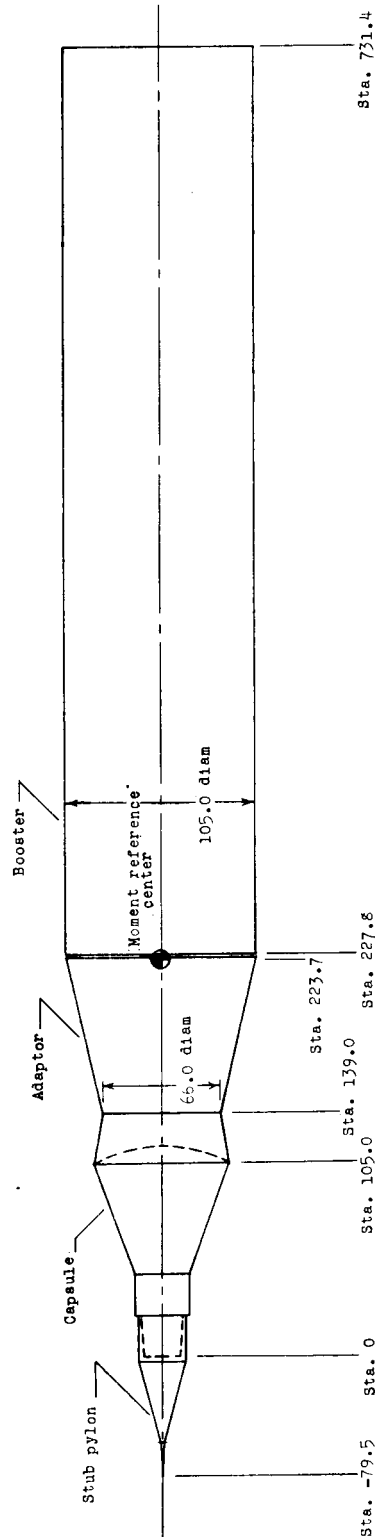
Figure 2.- Continued.

CONFIDENTIAL

0317120A.0300

12

CONFIDENTIAL



(c) Jupiter-Mercury configuration.

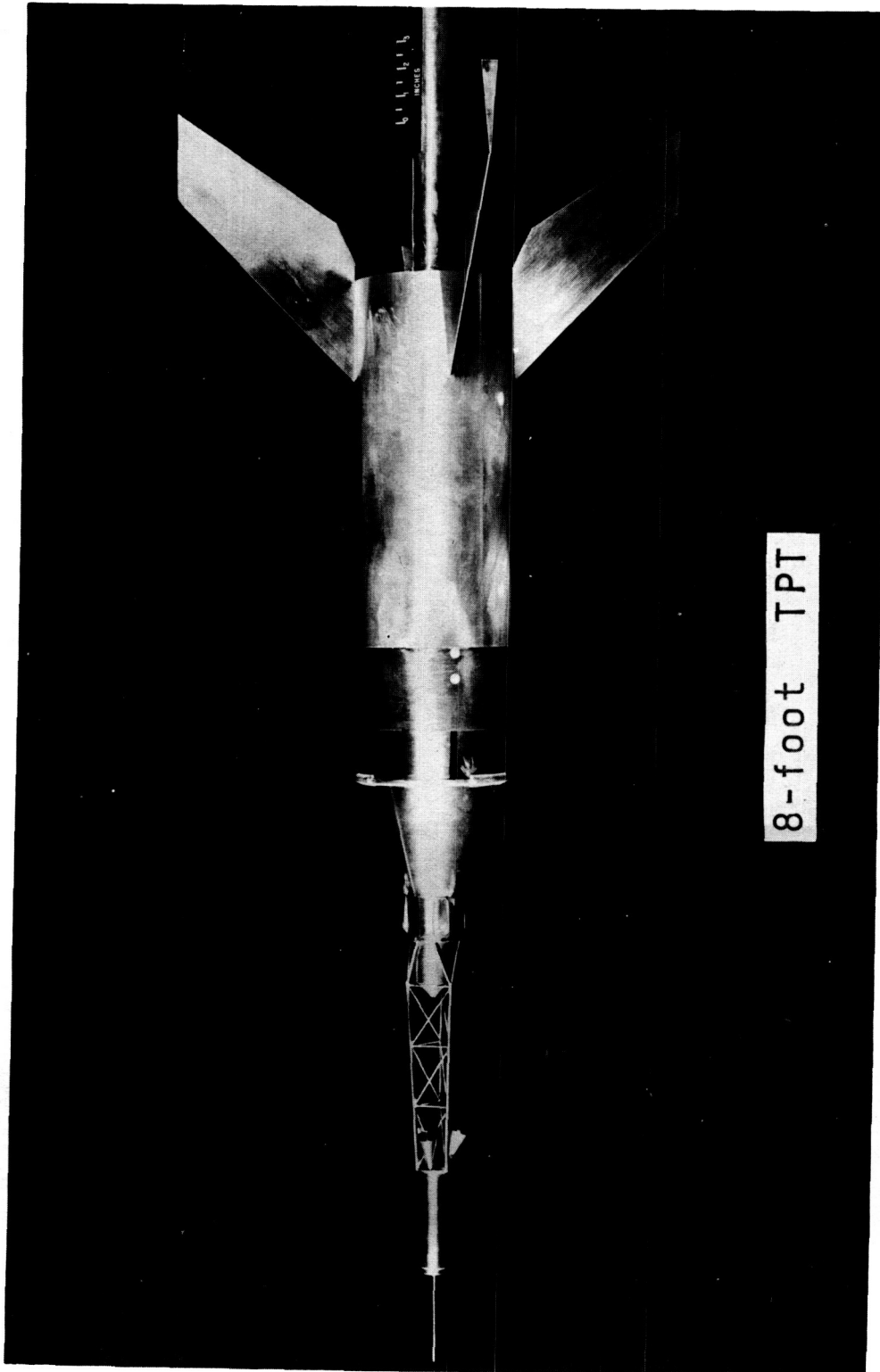
Figure 2.- Concluded.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

13



(a) Little Joe; escape. L-59-2387.1

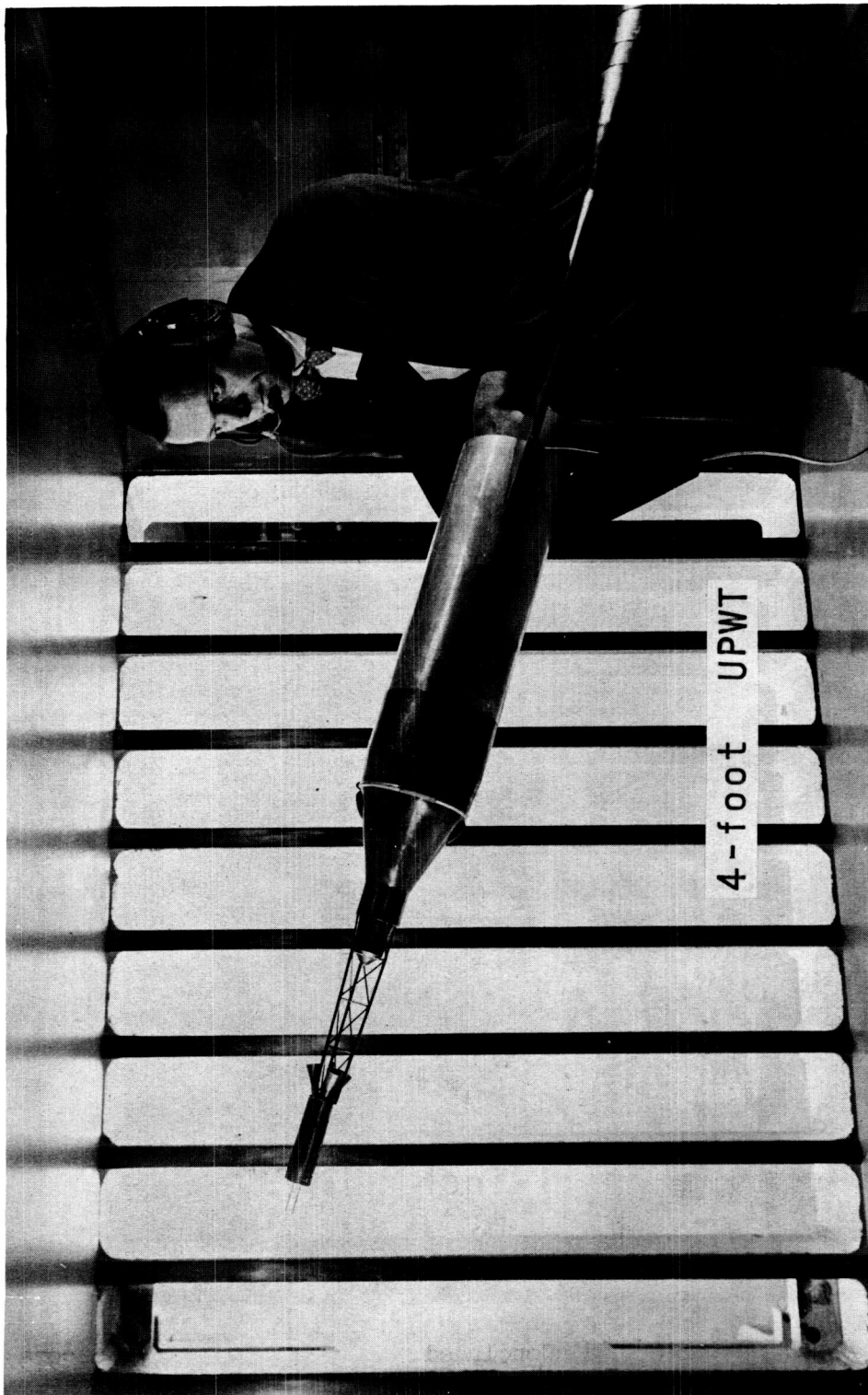
Figure 3.- Photographs of models.

CONFIDENTIAL

03:12:08.030

14

CONFIDENTIAL



L-59-4320.1

(a) Continued.

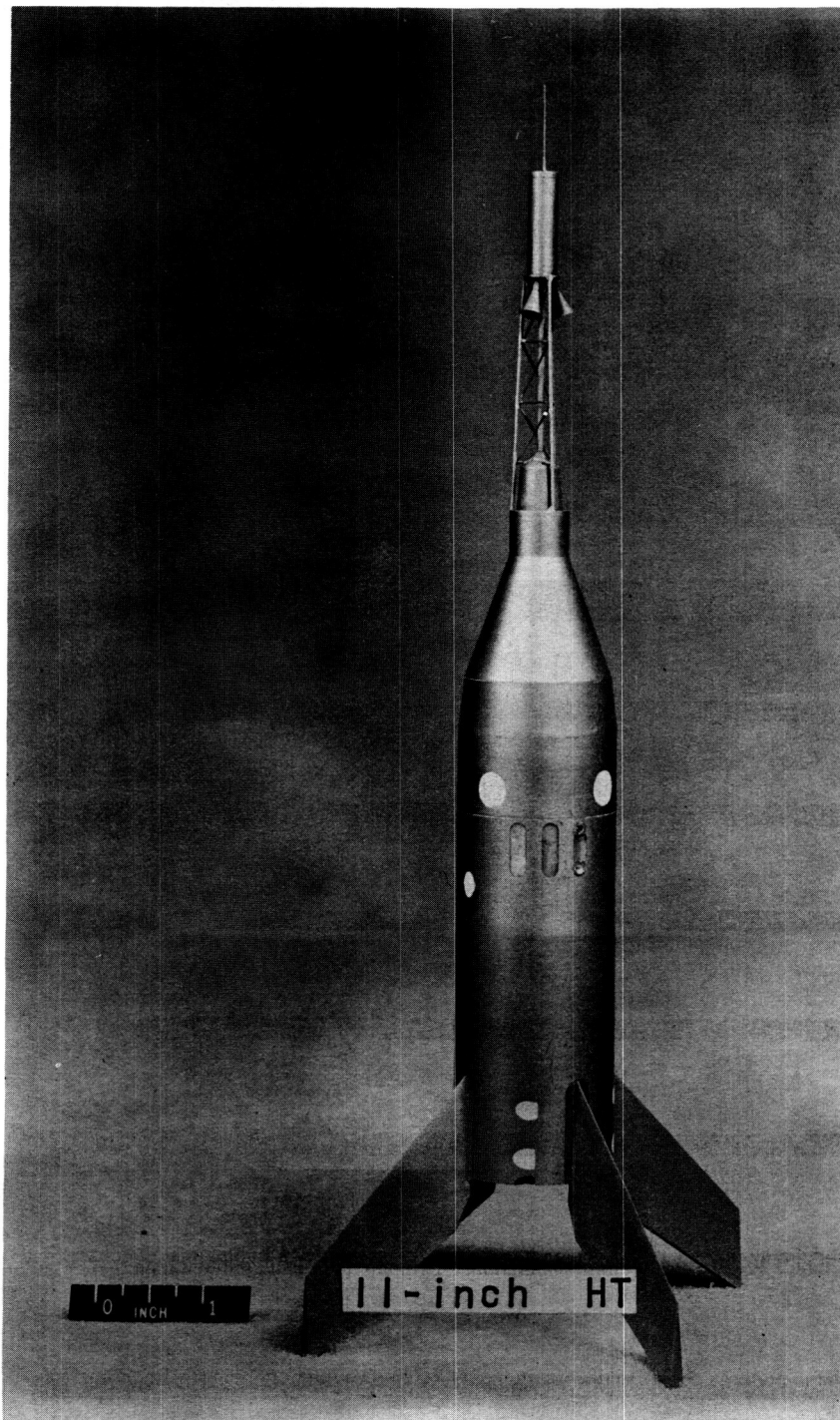
Figure 3.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

15



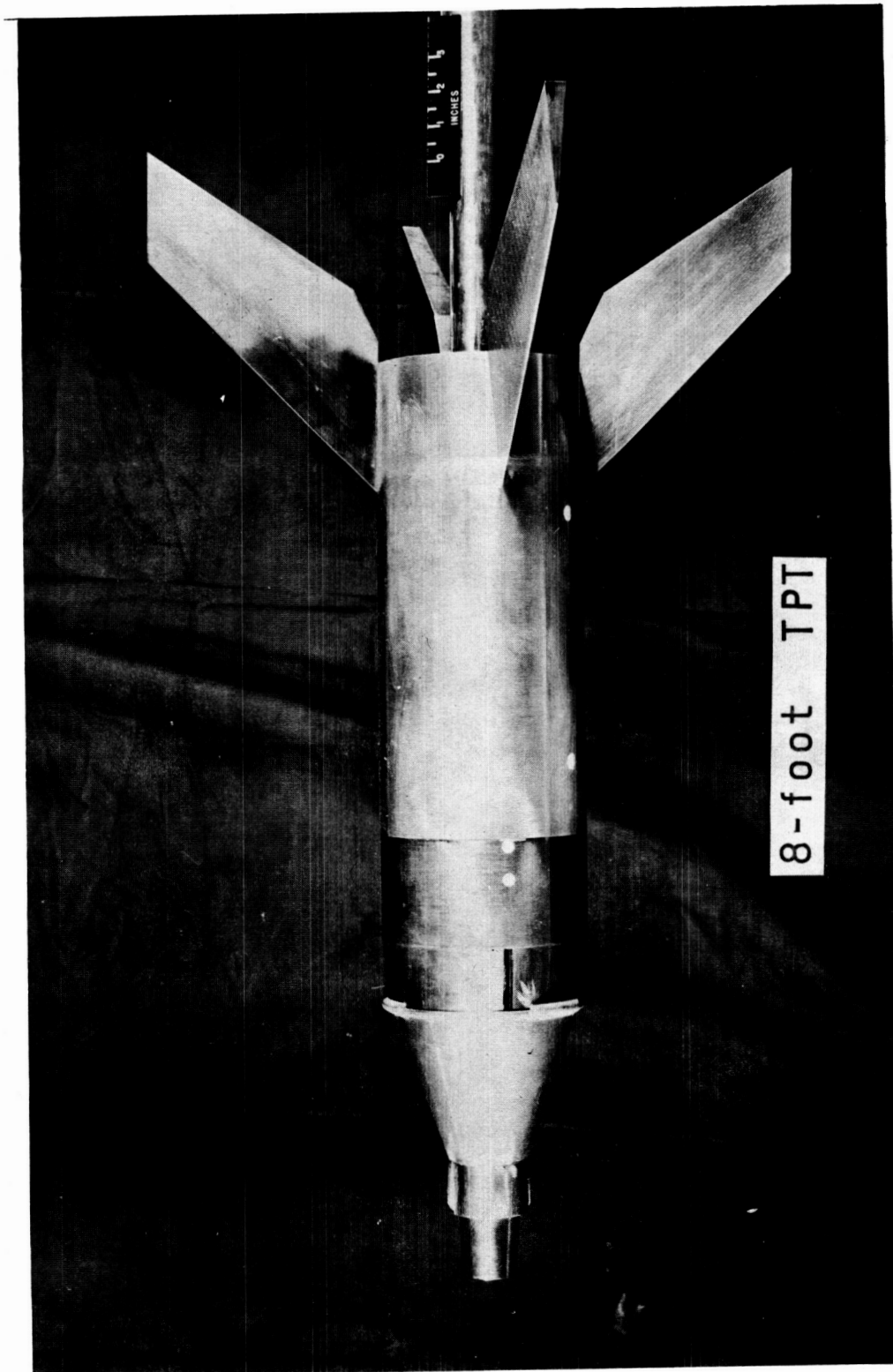
(a) Concluded.

L-59-2975.1

Figure 3.- Continued.

CONFIDENTIAL

CONFIDENTIAL



L-59-2389.1

(b) Little Joe; exit.

Figure 3.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

17



I-59-4322.1

(b) Continued.

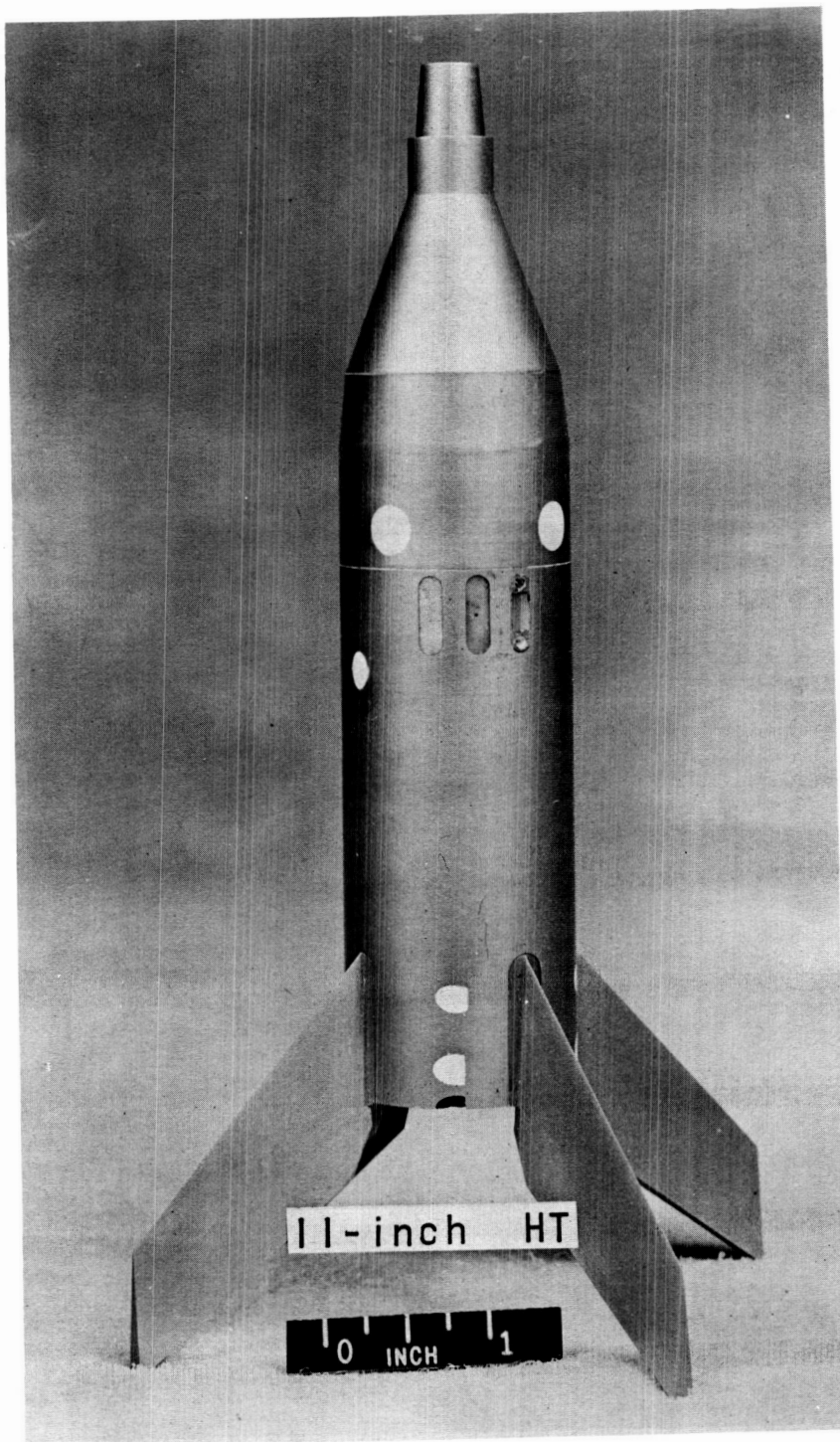
Figure 3.- Continued.

CONFIDENTIAL

03:41:20.1930

18

CONFIDENTIAL



(b) Concluded.

L-59-2976.1

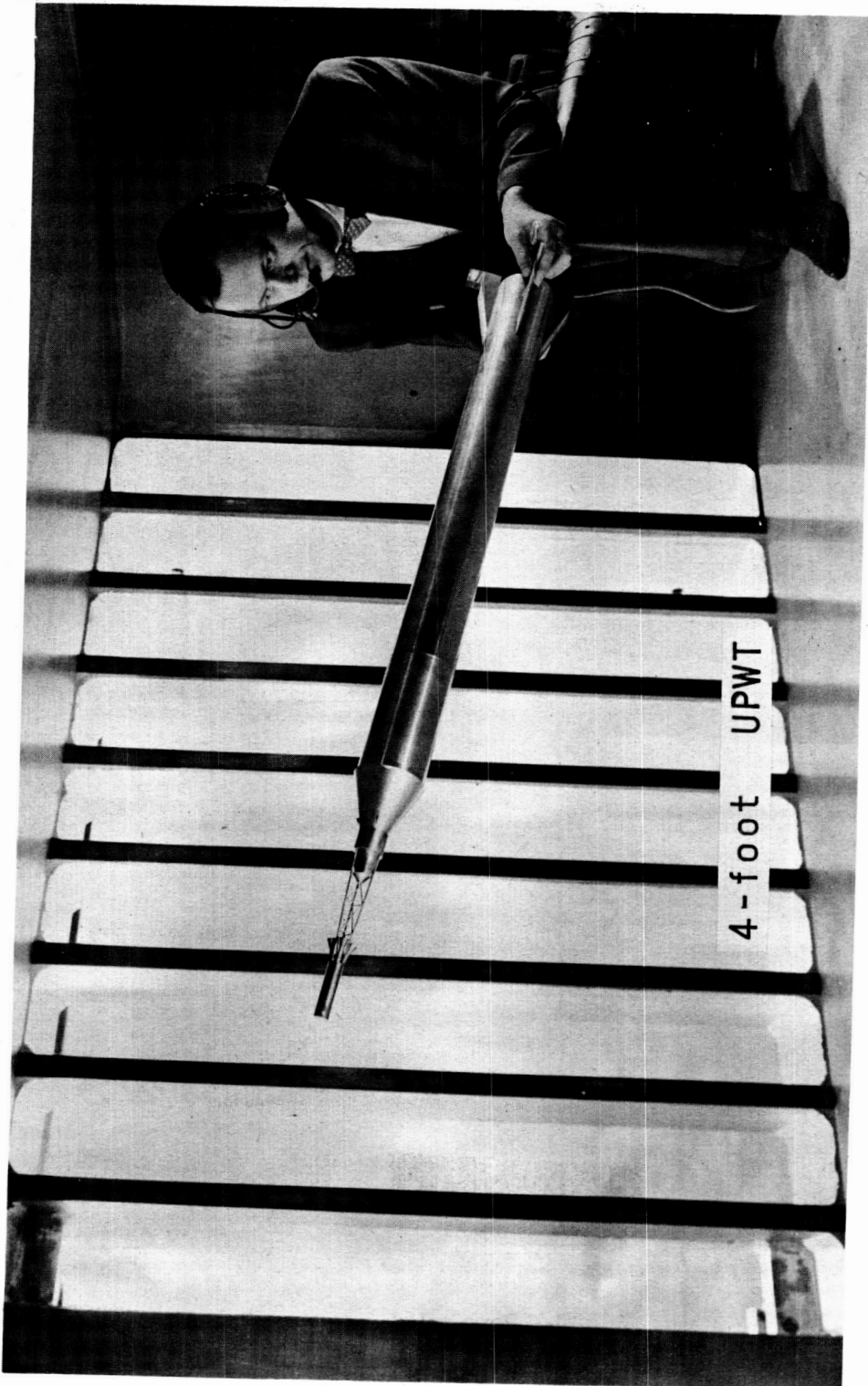
Figure 3.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

19



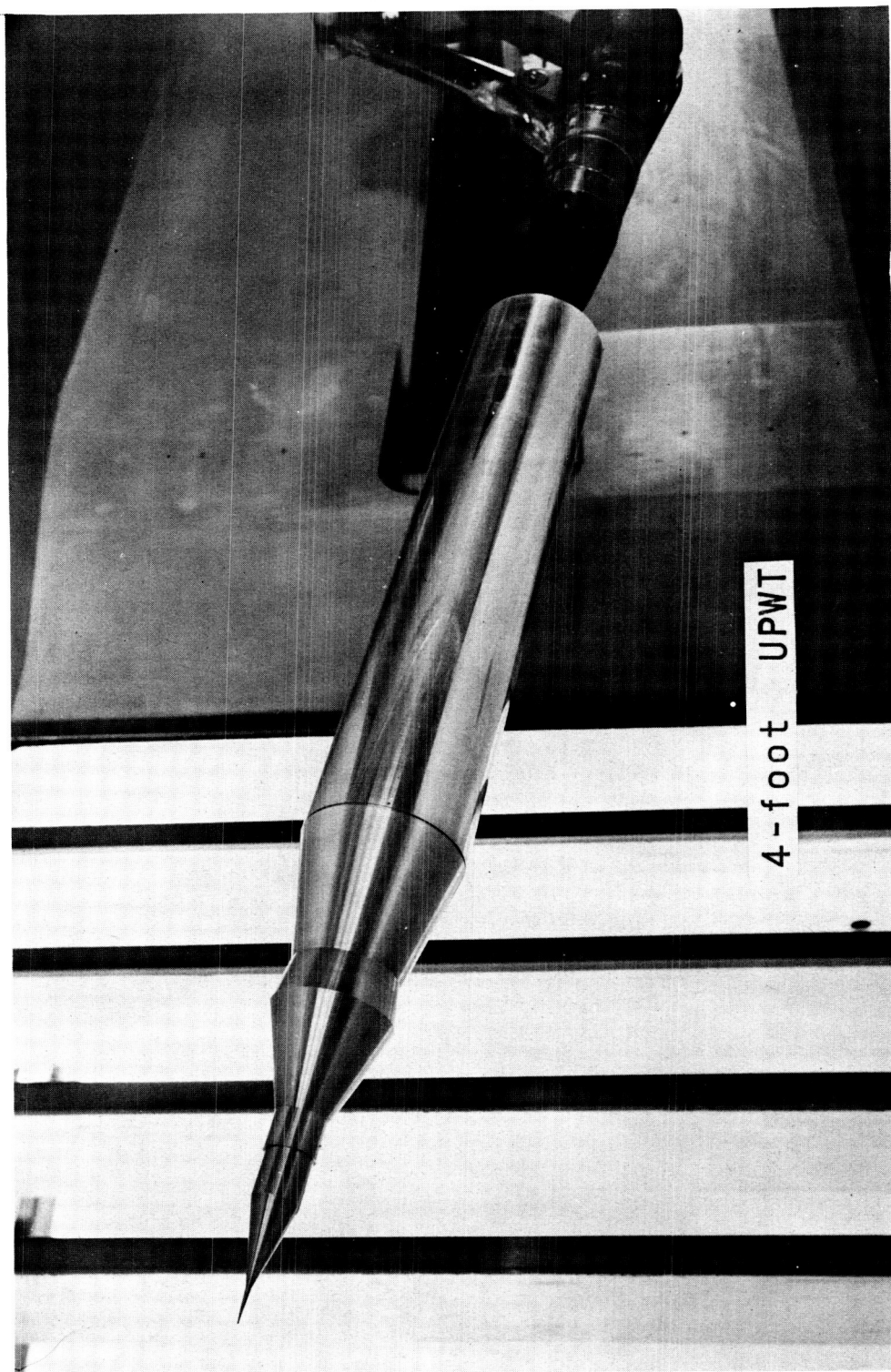
(c) Redstone-Mercury.  
Figure 3.- Continued.

CONFIDENTIAL

031710281030

20

CONFIDENTIAL



L-59-4340.1

(d) Jupiter-Mercury.

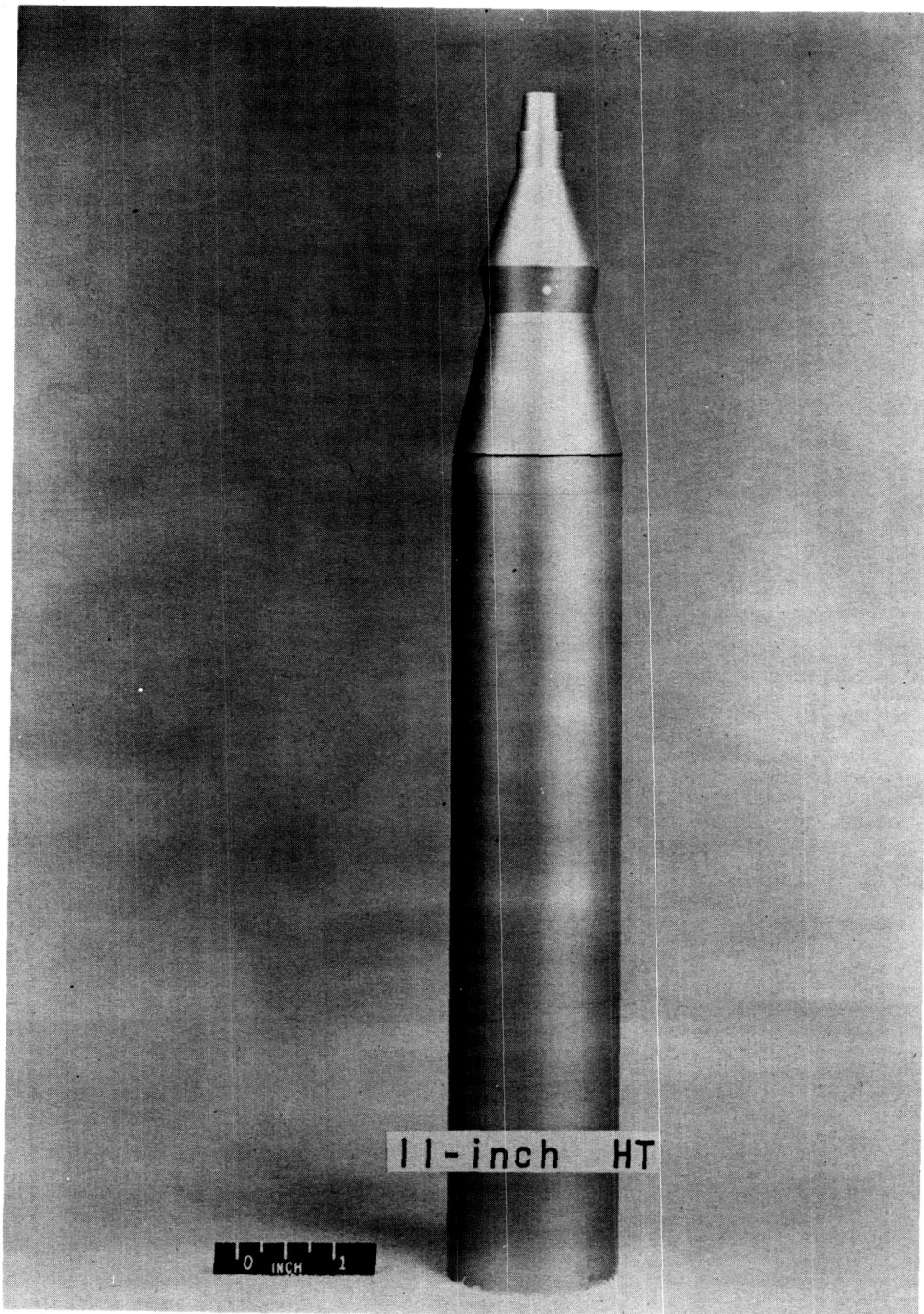
Figure 3.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

21



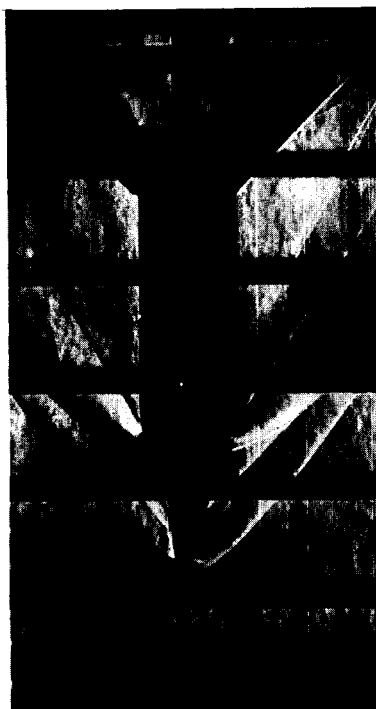
(d) Concluded.

L-59-2977.1

Figure 3.- Concluded.

CONFIDENTIAL

CONFIDENTIAL

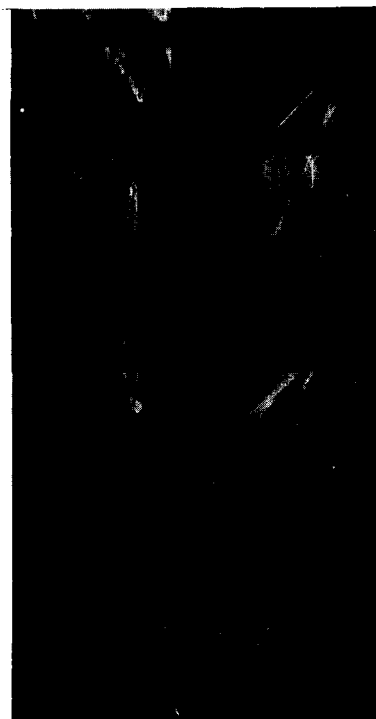


$\alpha=0^\circ$



$\alpha=7.0^\circ$   
M=1.82  
Exit

L-60-5596



$\alpha=0^\circ$



$\alpha=7.0^\circ$   
M=2.10  
Escape

(a) Little Joe.

Figure 4.- Typical schlieren photographs.

DECLASSIFIED

CONFIDENTIAL

23



$\alpha = 0^\circ$

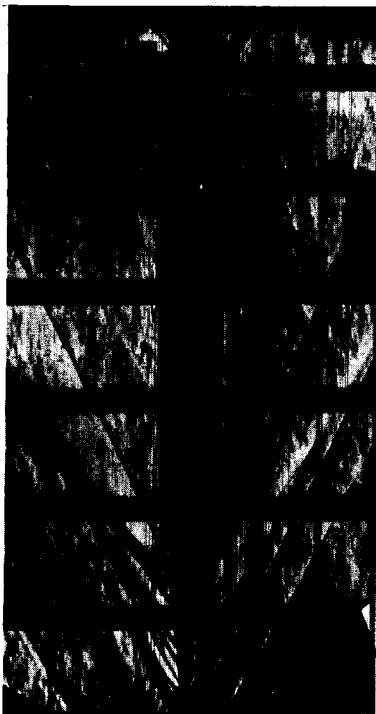


$\alpha = 8.0^\circ$

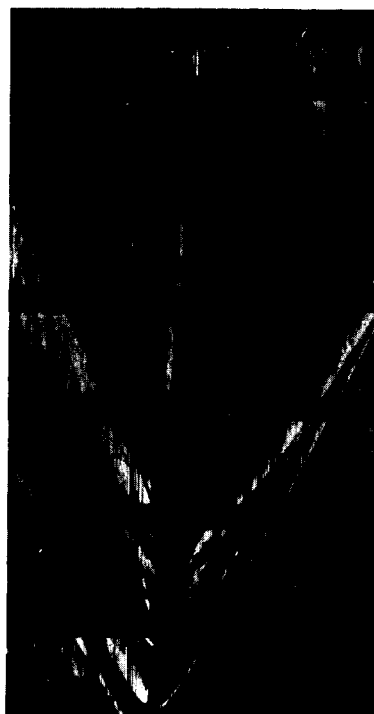
Jupiter-Mercury

L-60-5597

(b) Redstone-Mercury and Jupiter-Mercury;  $M = 2.10$ .



$\alpha = 0^\circ$



$\alpha = 8.0^\circ$

Redstone-Mercury

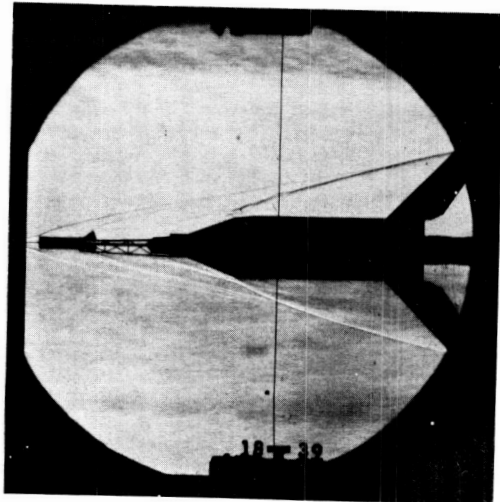
Figure 4.- Continued.

CONFIDENTIAL

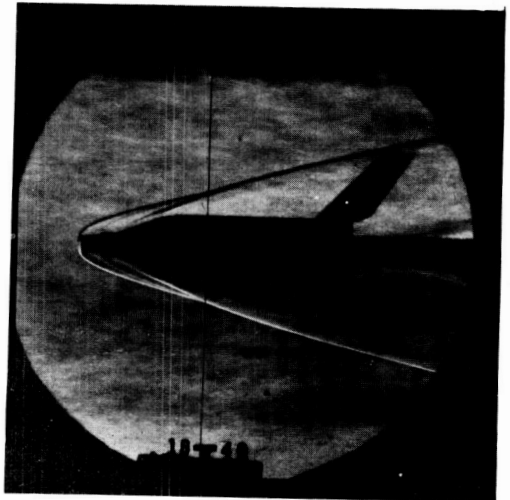
0371228.1030

24

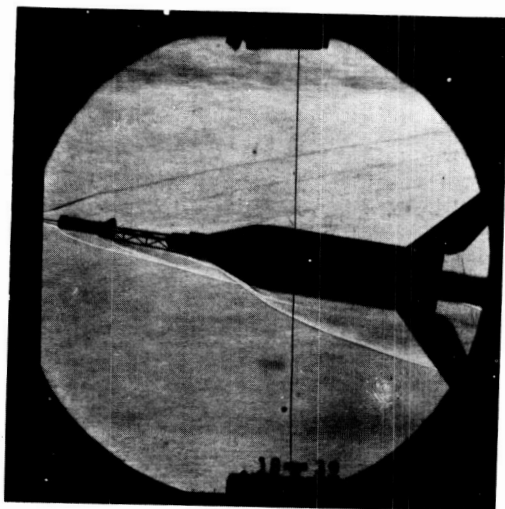
CONFIDENTIAL



$\alpha = 0^\circ$

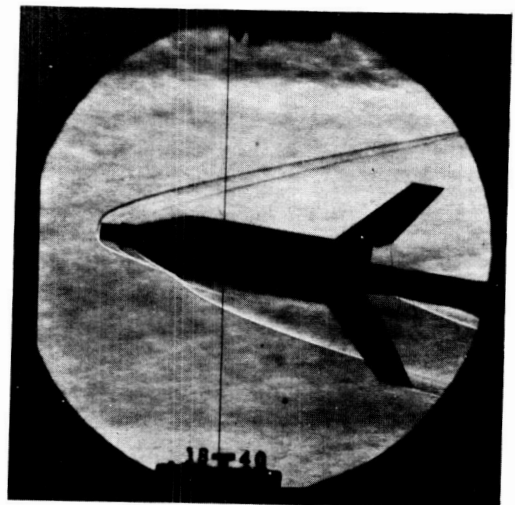


$\alpha = 0^\circ$



$\alpha = 8.0^\circ$

Escape



$\alpha = 8.0^\circ$

Exit

(c) Little Joe; M = 6.8.

L-60-5598

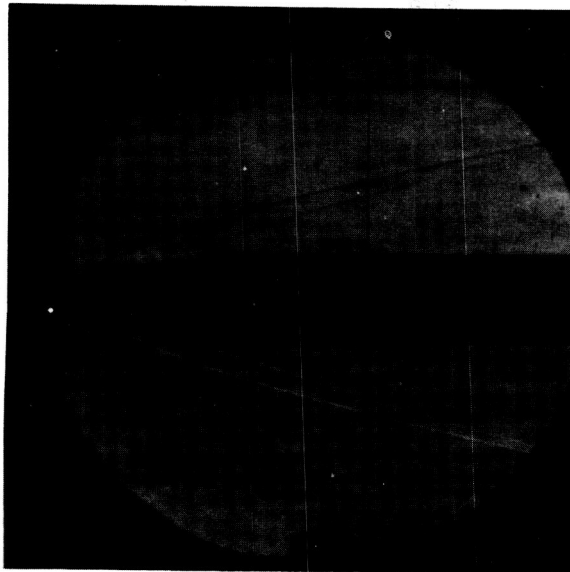
Figure 4.- Continued.

CONFIDENTIAL

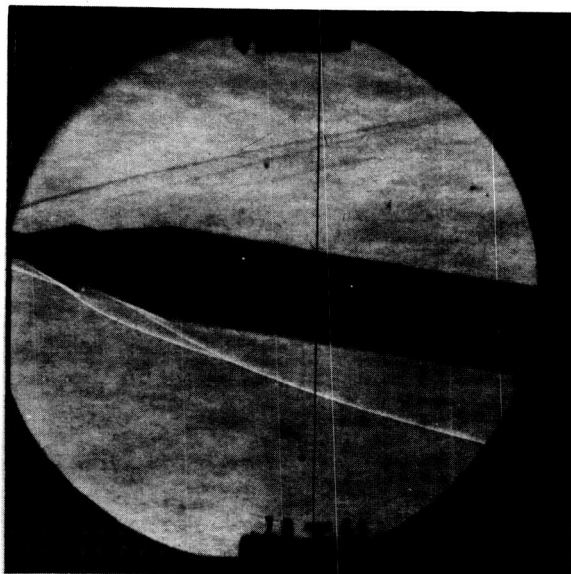
DECLASSIFIED

CONFIDENTIAL

25



$\alpha = 0.1^\circ$



$\alpha = 8.5^\circ$

(d) Jupiter-Mercury;  $M = 6.7$ .

L-60-5599

Figure 4.- Concluded.

CONFIDENTIAL

0371028.1030

26

CONFIDENTIAL

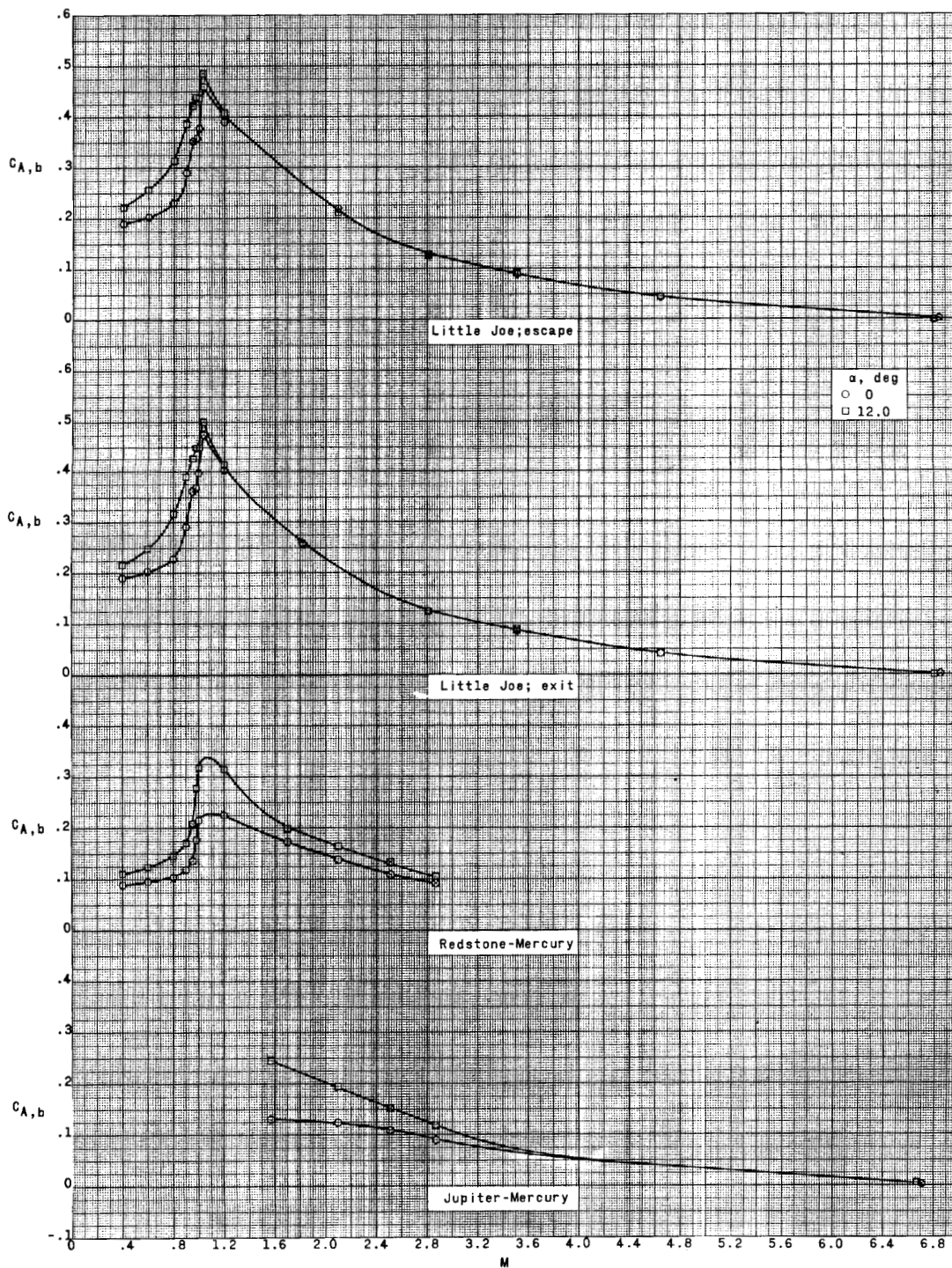


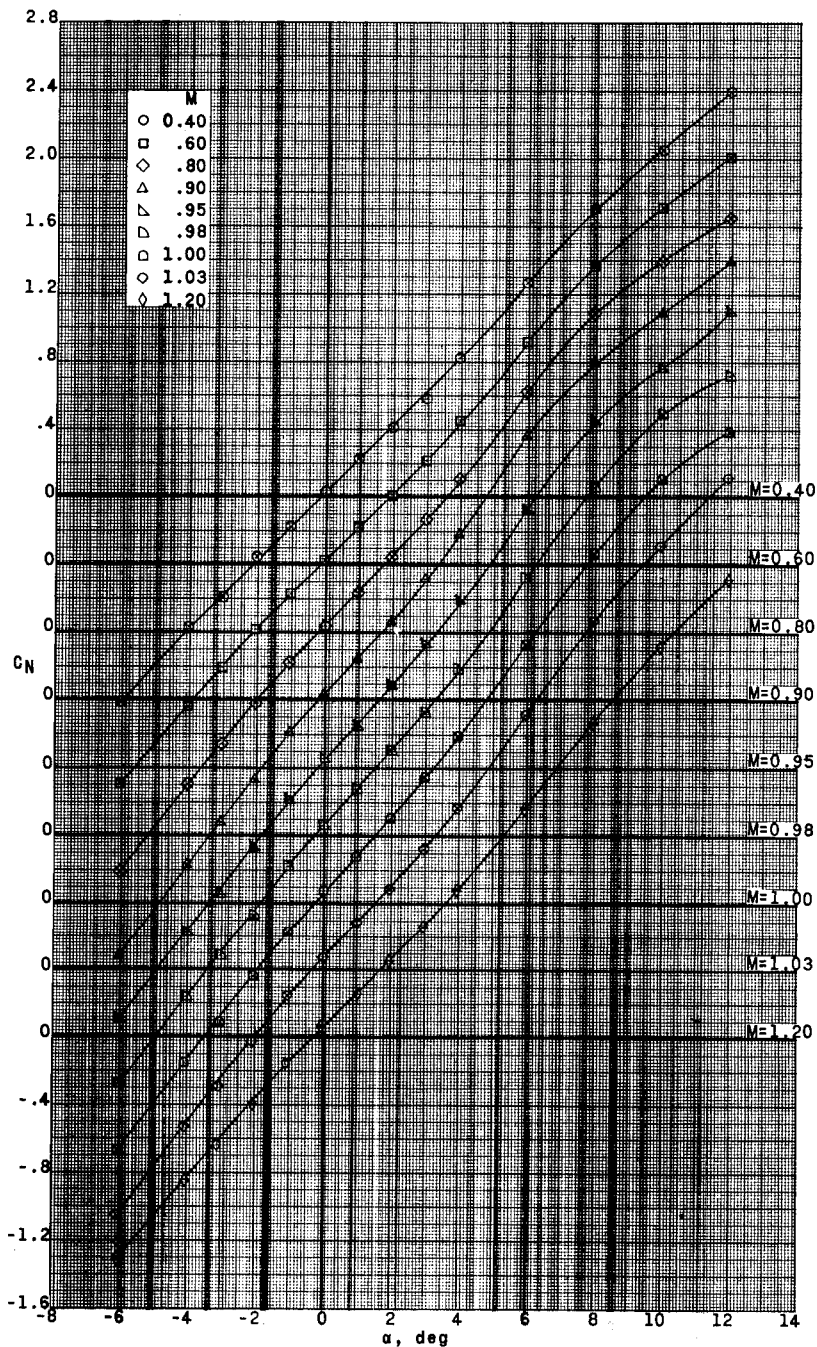
Figure 5.- Variation of base axial-force coefficients with Mach number.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

27



(a) 8-foot TPT.

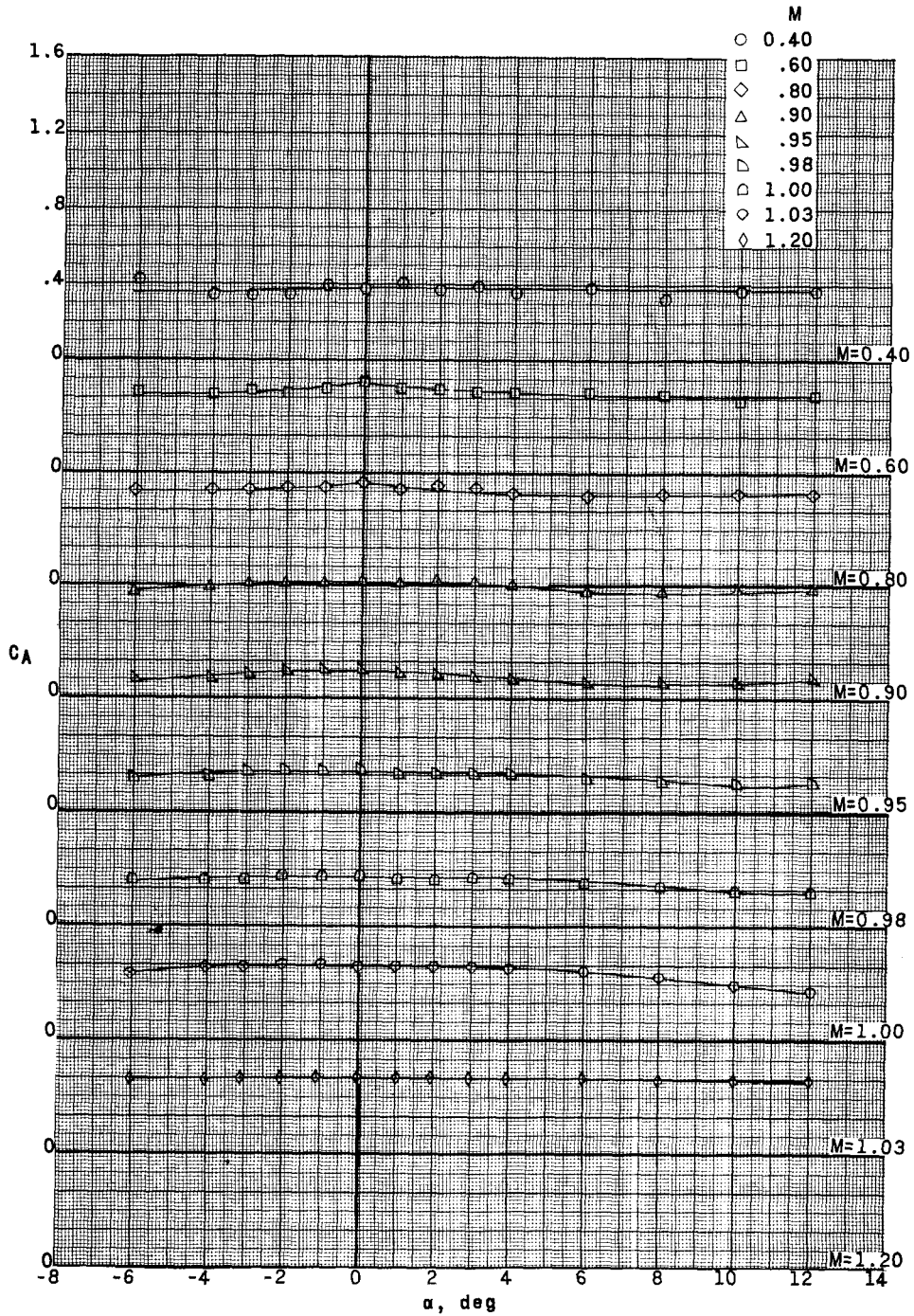
Figure 6.- Aerodynamic characteristics of Little Joe escape configuration. Moment reference center at station 372.4.

CONFIDENTIAL

03710241030

28

CONFIDENTIAL



(a) Continued.

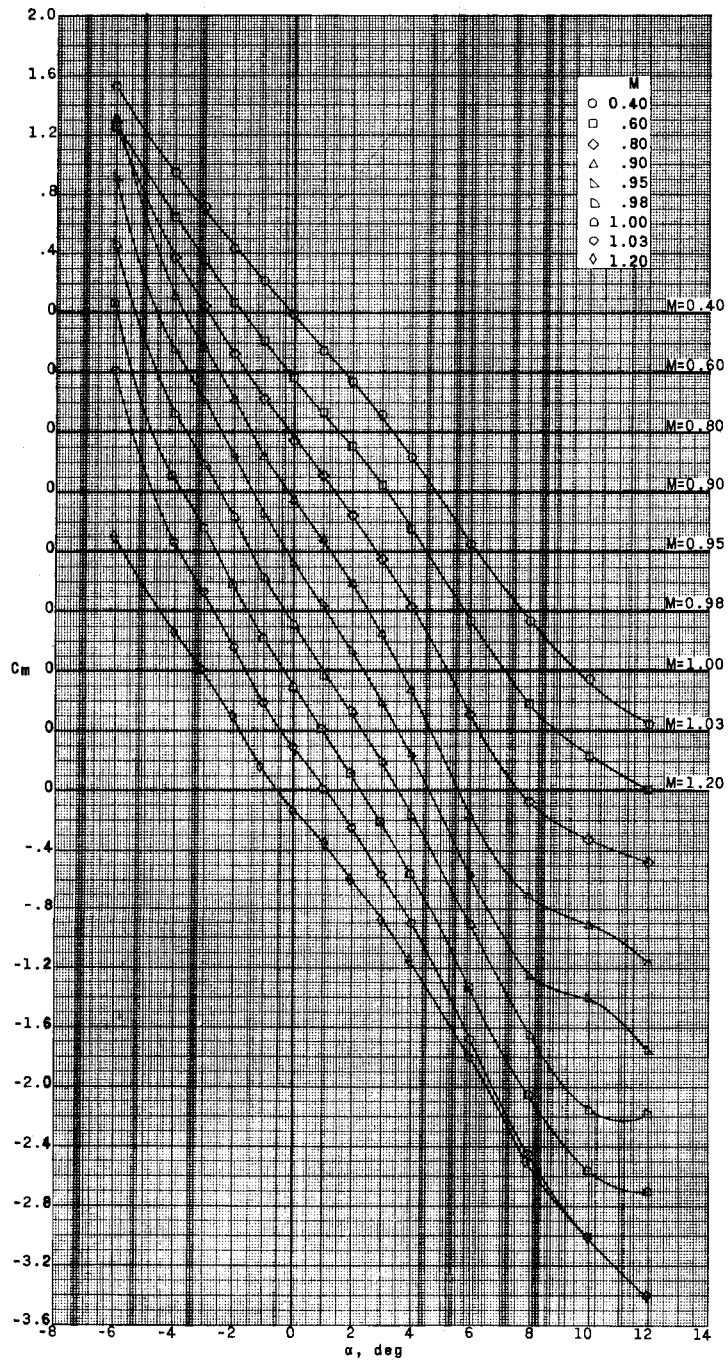
Figure 6.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

29



(a) Concluded.

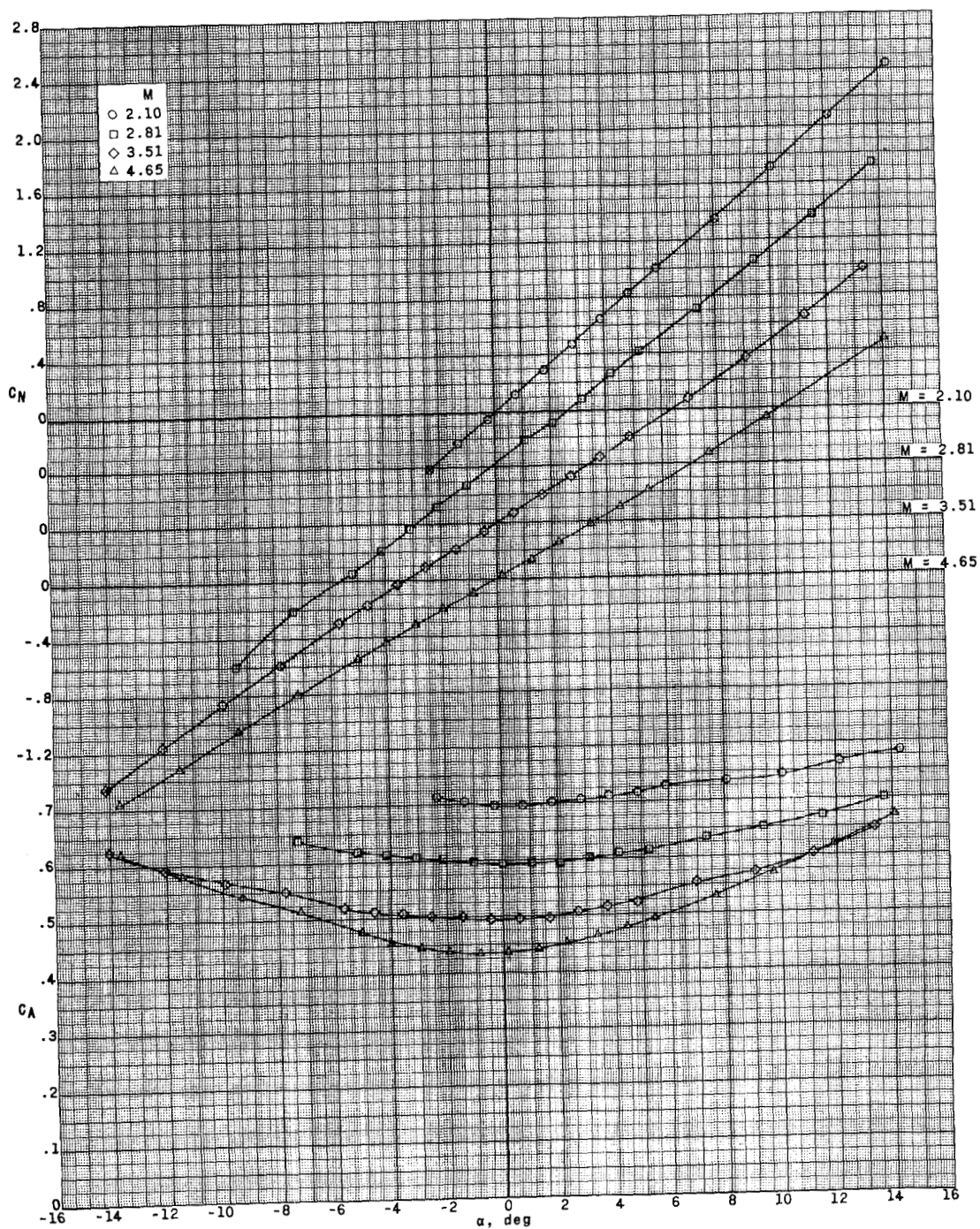
Figure 6.- Continued.

CONFIDENTIAL

03172201030

30

CONFIDENTIAL



(b) 4-foot UPWT.

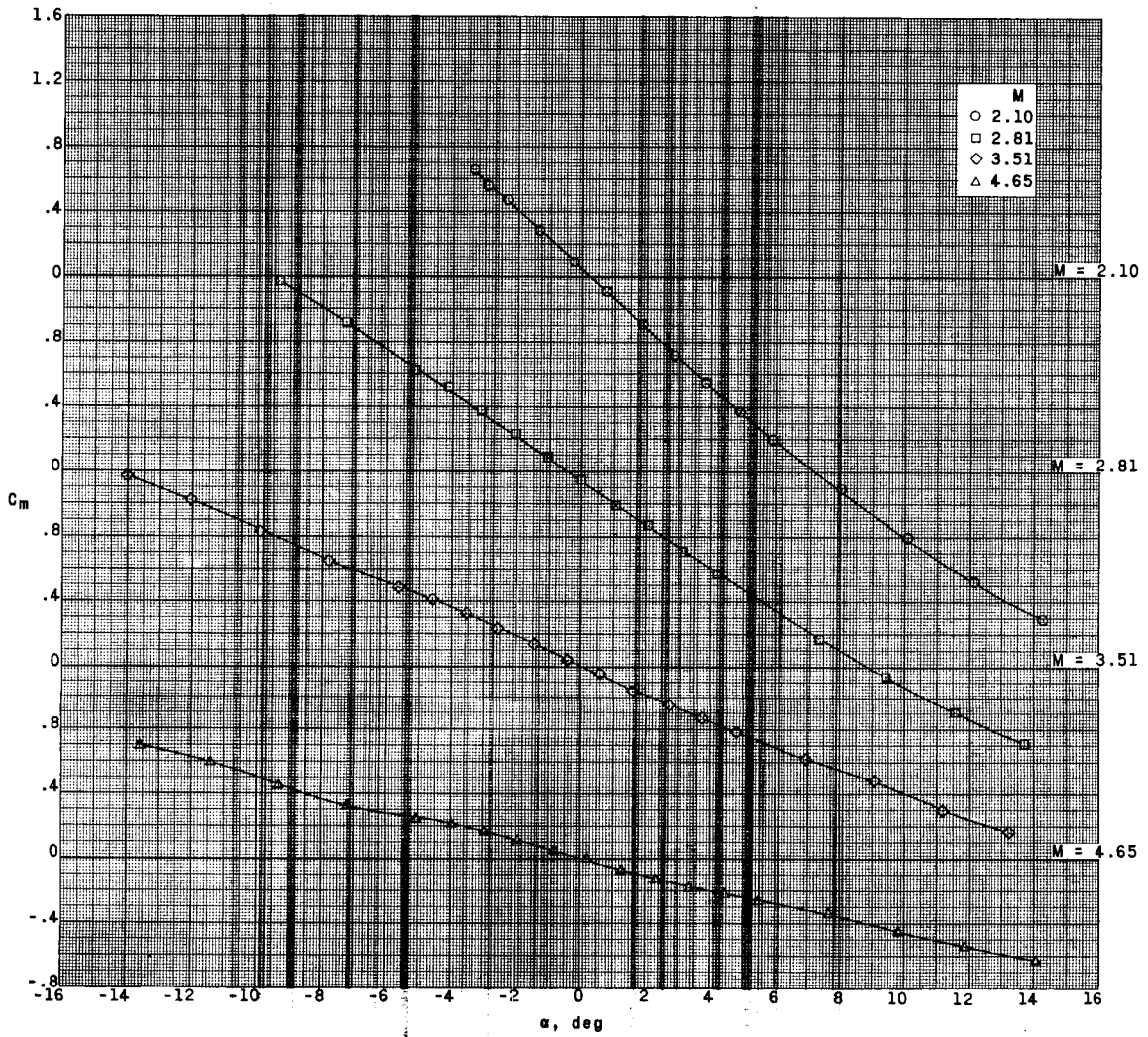
Figure 6.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

31



(b) Concluded.

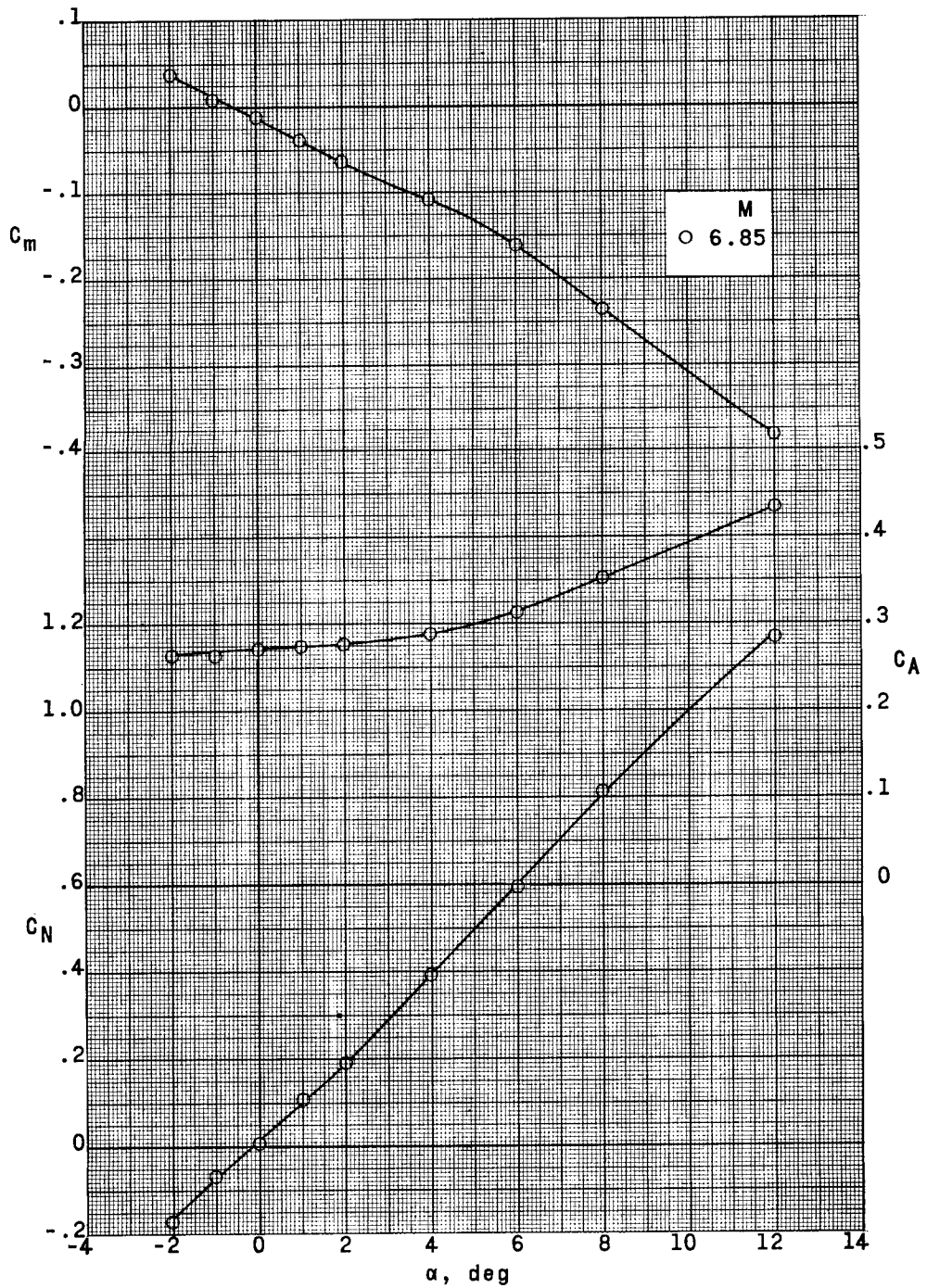
Figure 6.- Continued.

CONFIDENTIAL

031715201030

32

CONFIDENTIAL



(c) 11-inch HT.

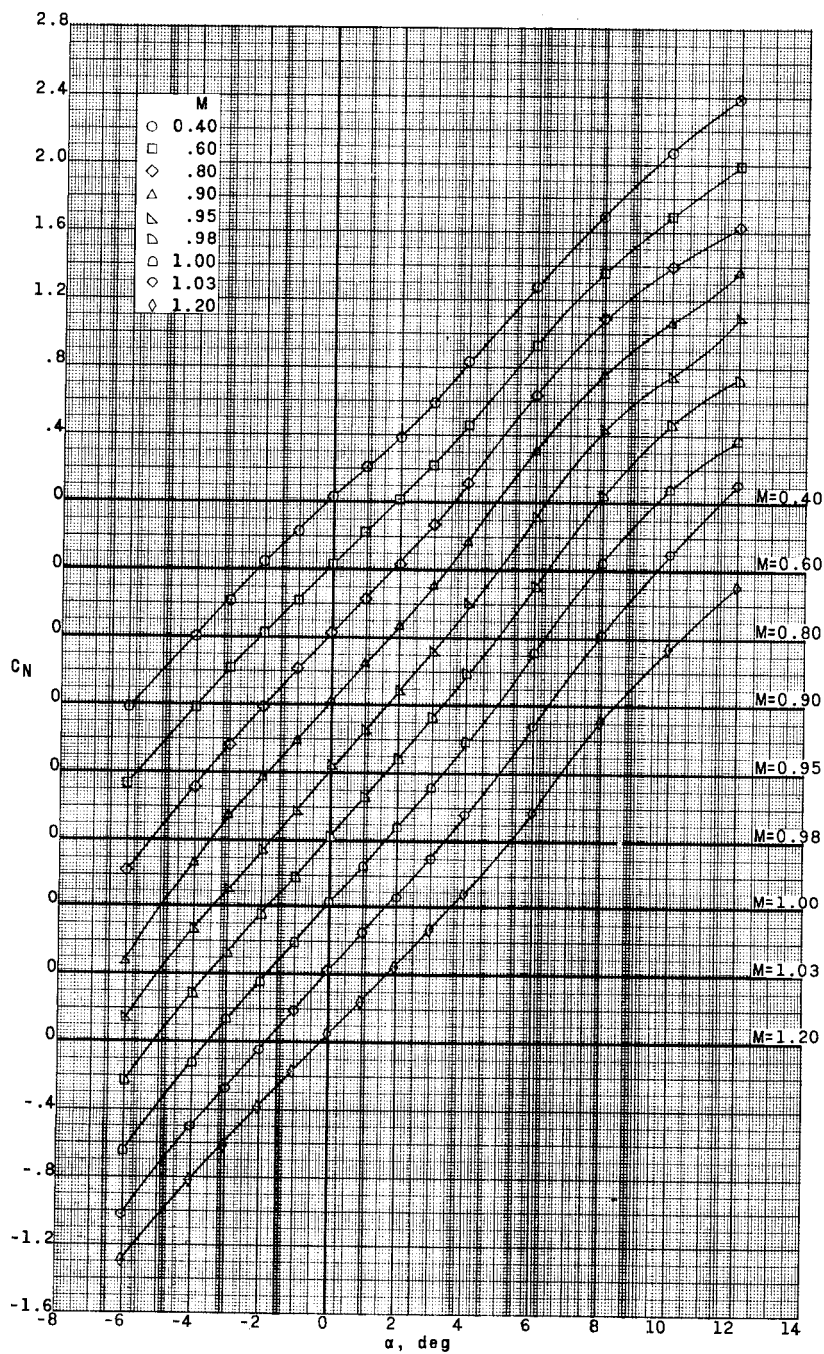
Figure 6.- Concluded.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

33



(a) 8-foot TPT.

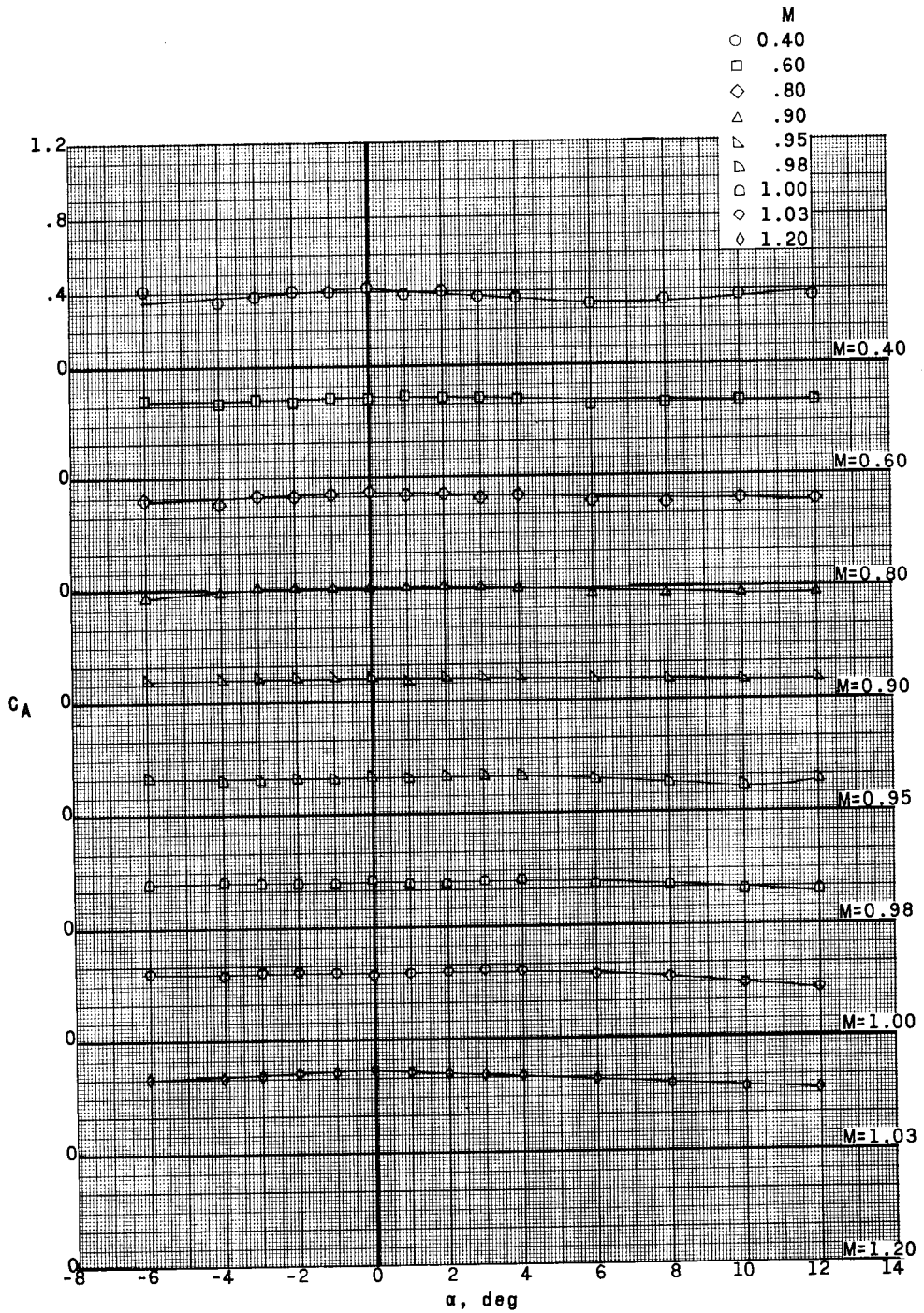
Figure 7.- Aerodynamic characteristics of Little Joe exit configuration.  
Moment reference center at station 399.6.

CONFIDENTIAL

031712201030

34

CONFIDENTIAL



(a) Continued.

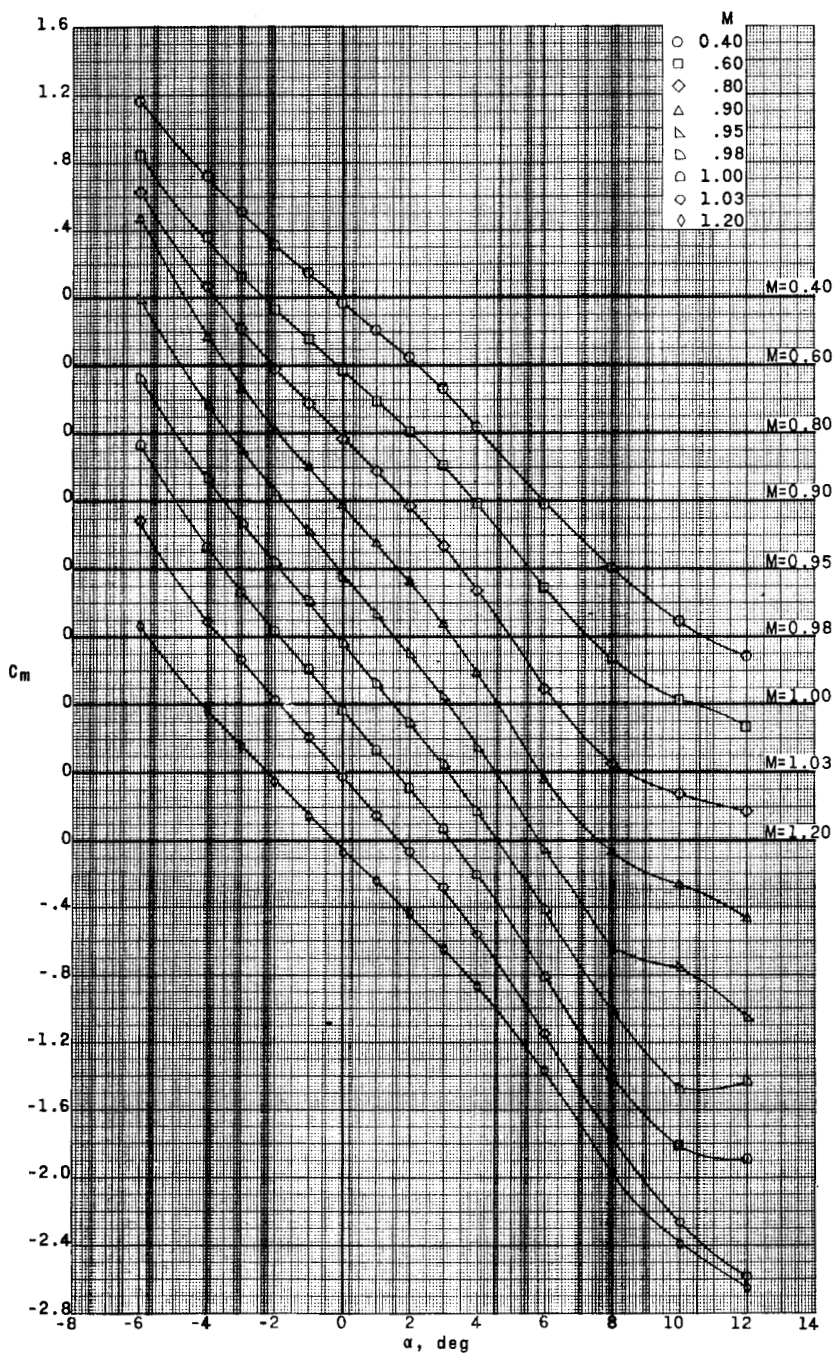
Figure 7.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

35



(a) Concluded.

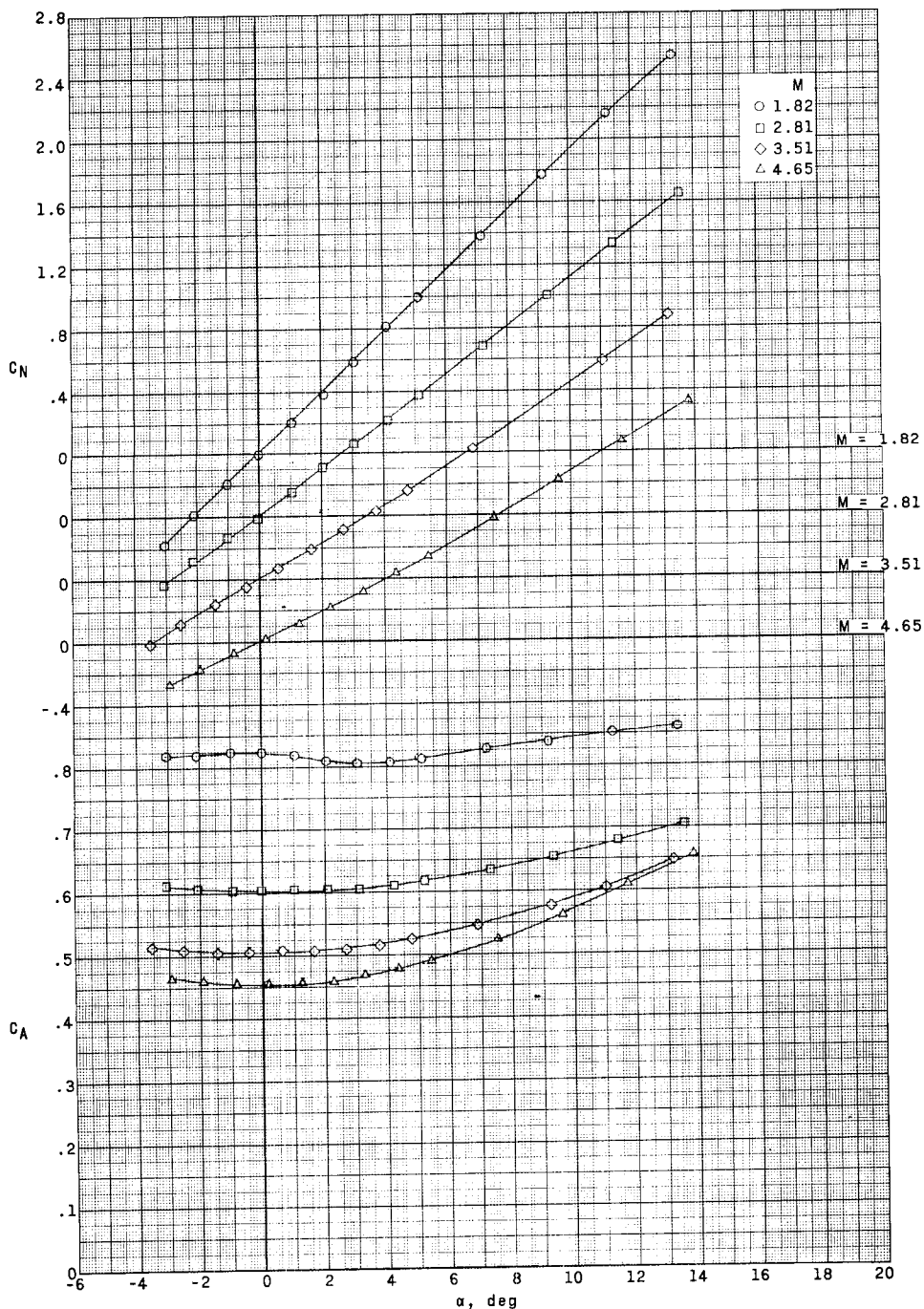
Figure 7.- Continued.

CONFIDENTIAL

091715Z01030

36

CONFIDENTIAL



(b) 4-foot UPWT.

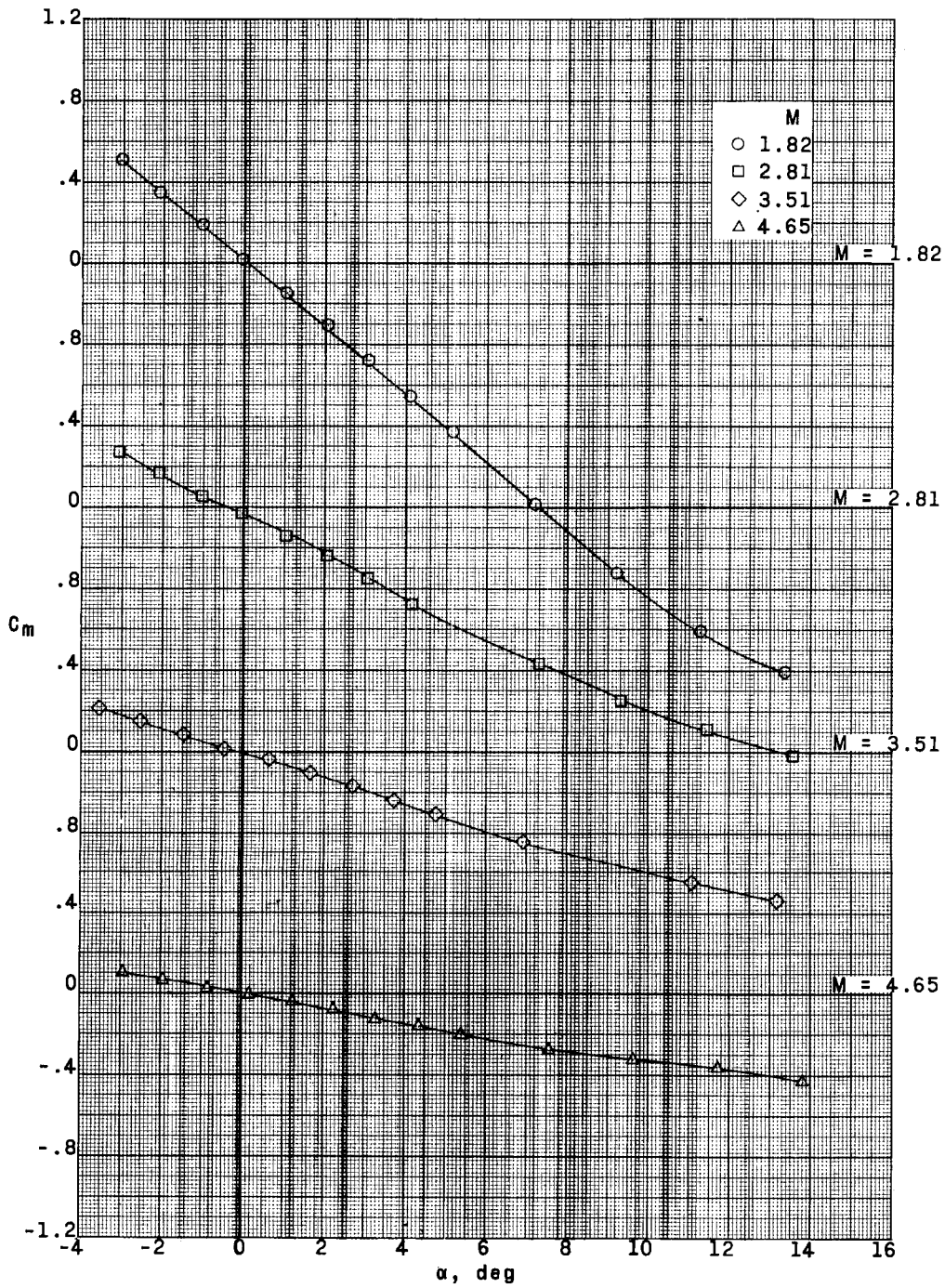
Figure 7.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

37



(b) Concluded.

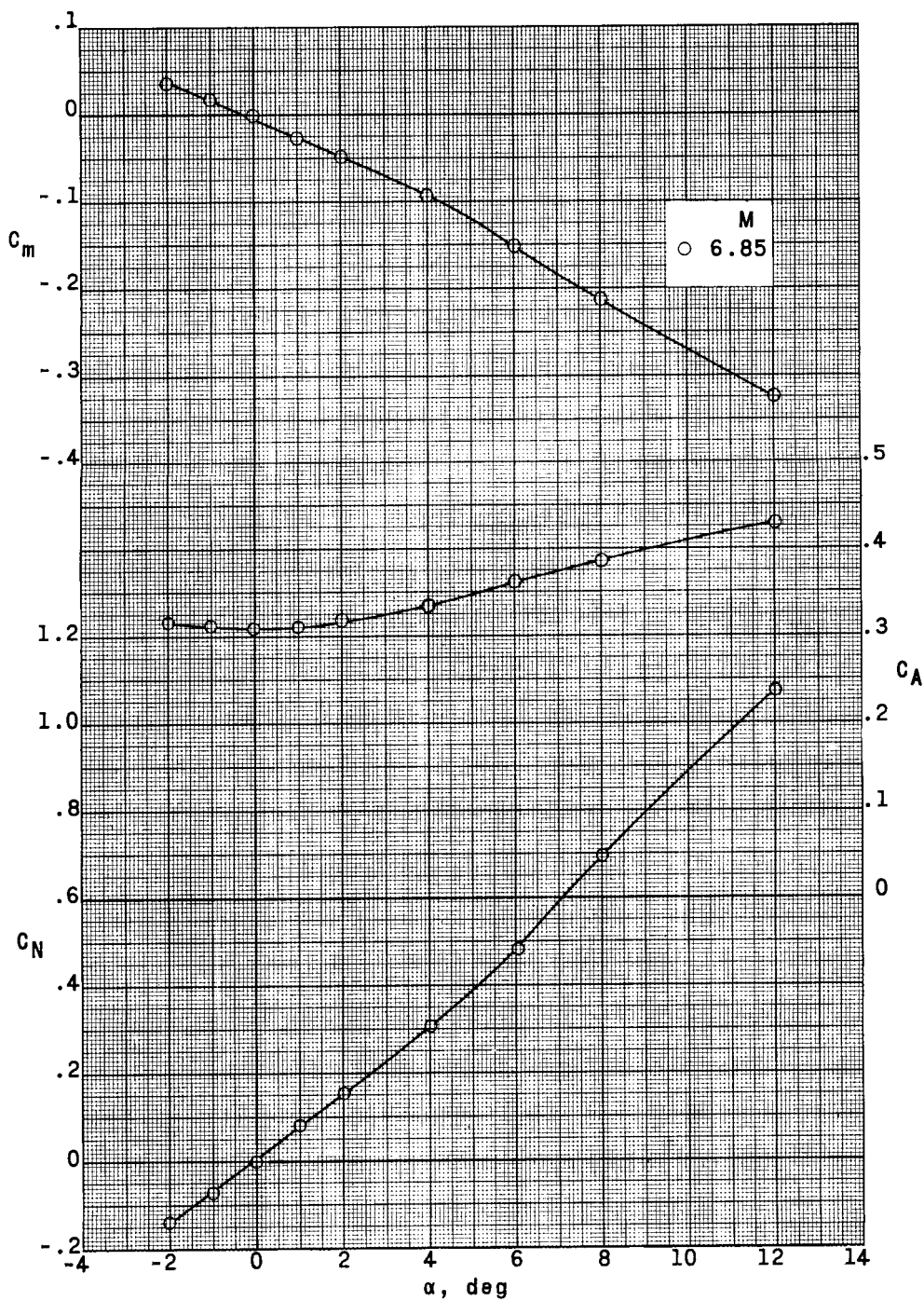
Figure 7.- Continued.

CONFIDENTIAL

03715201030

38

CONFIDENTIAL



(c) 11-inch HT.

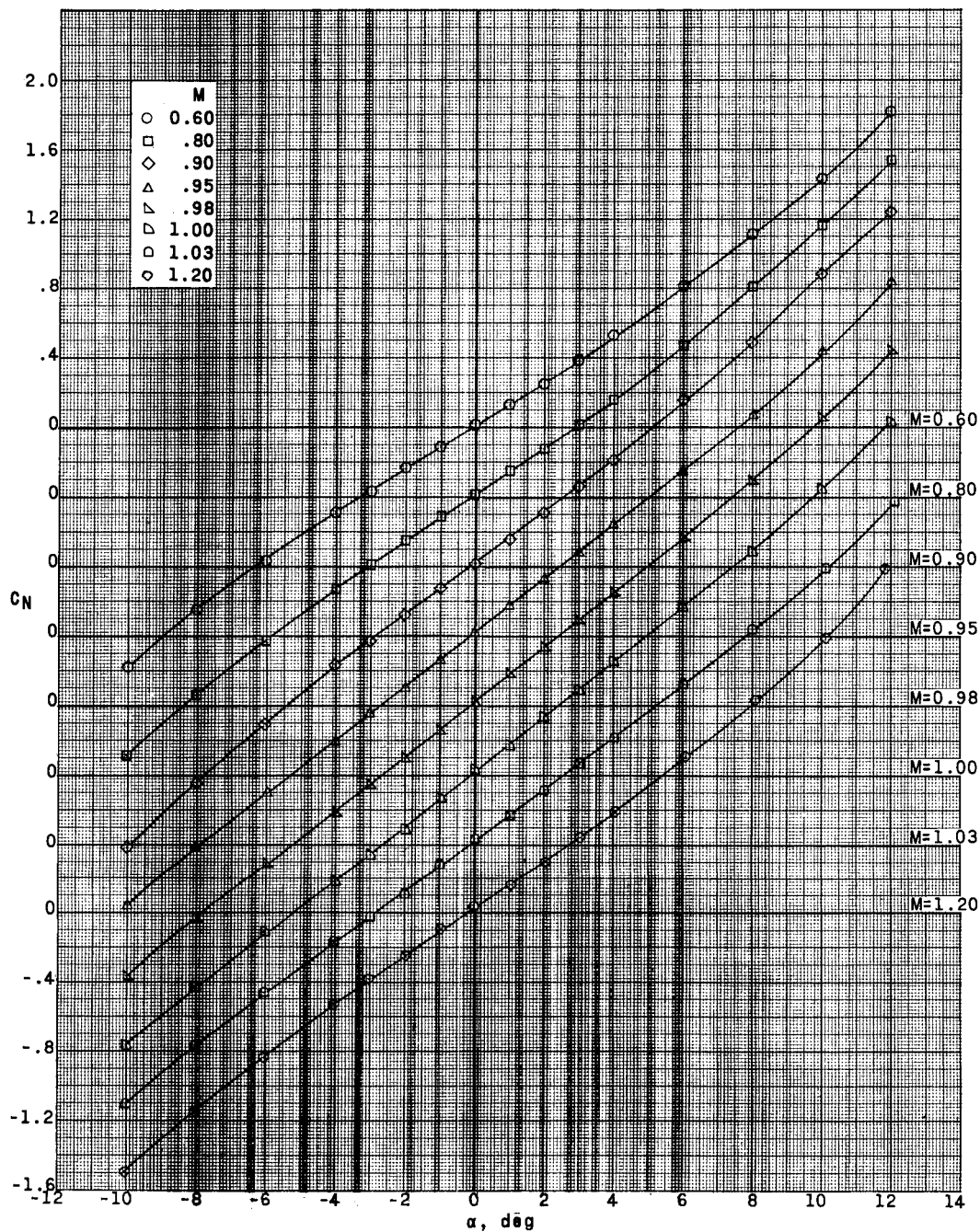
Figure 7.- Concluded.

CONFIDENTIAL

# DECLASSIFIED

CONFIDENTIAL

39

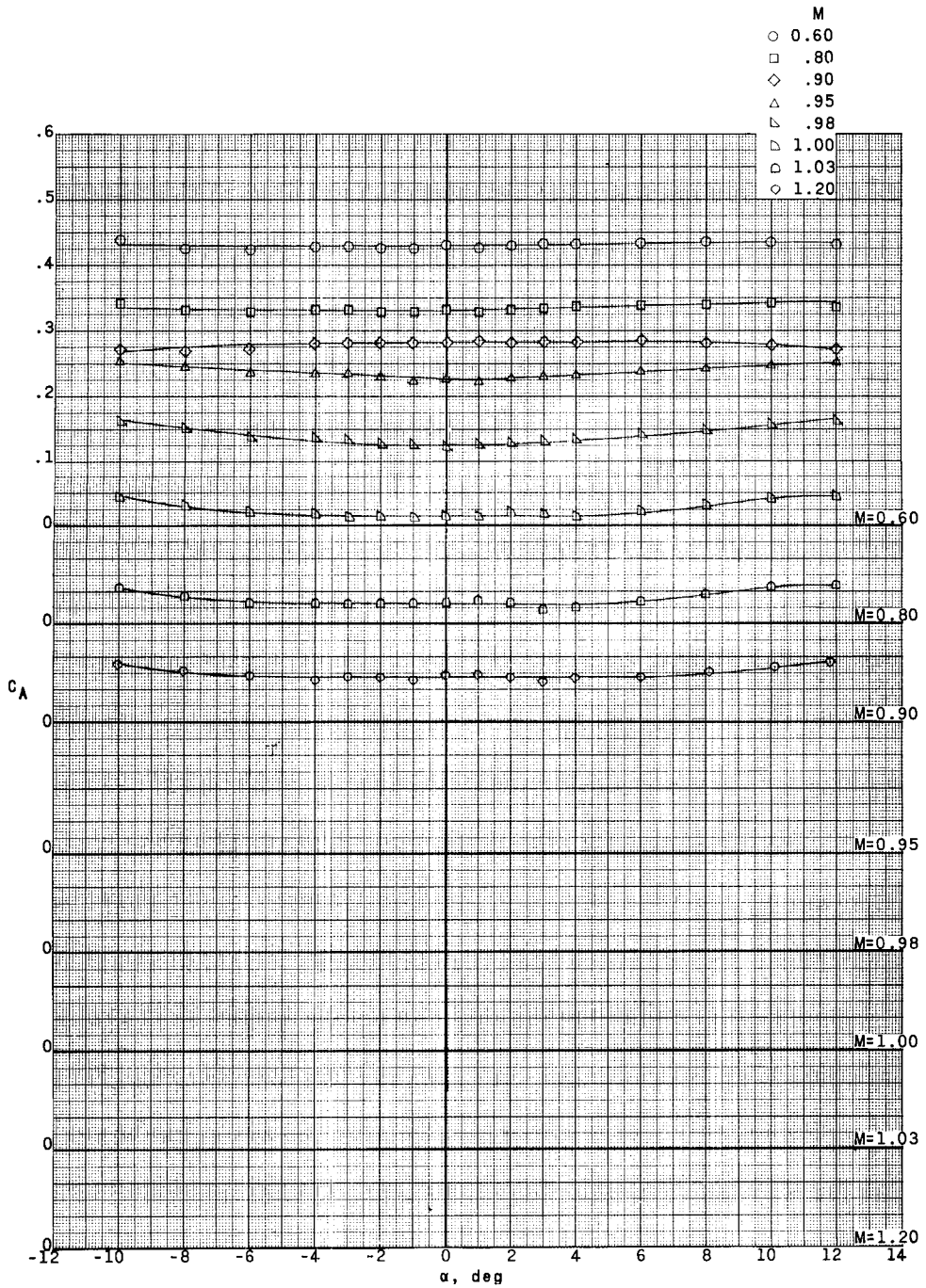


(a) 8-foot TPT.

Figure 8.- Aerodynamic characteristics of Redstone-Mercury configuration. Moment reference center at station 357.4.

CONFIDENTIAL

CONFIDENTIAL



(a) Continued.

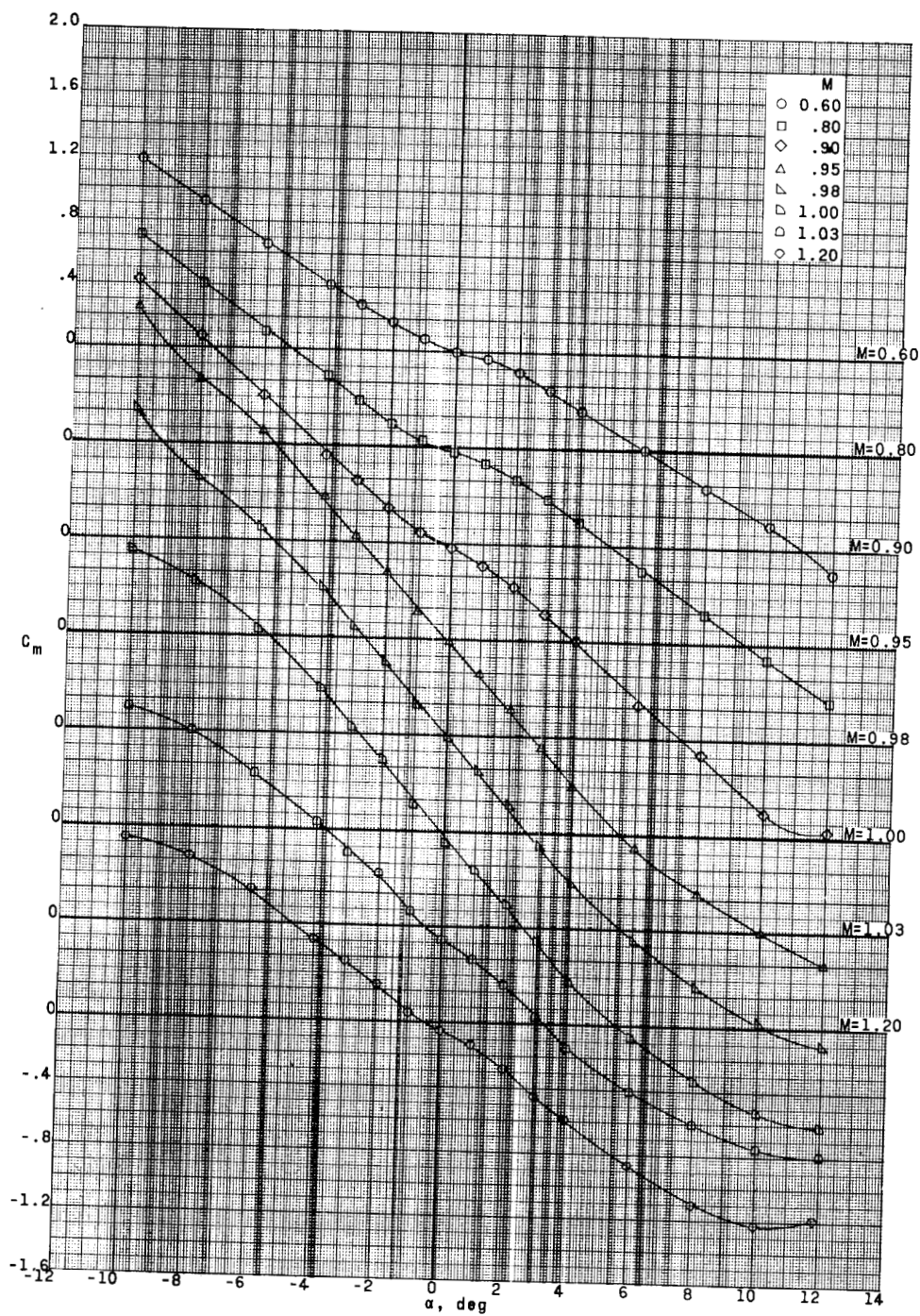
Figure 8.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

41



(a) Concluded.

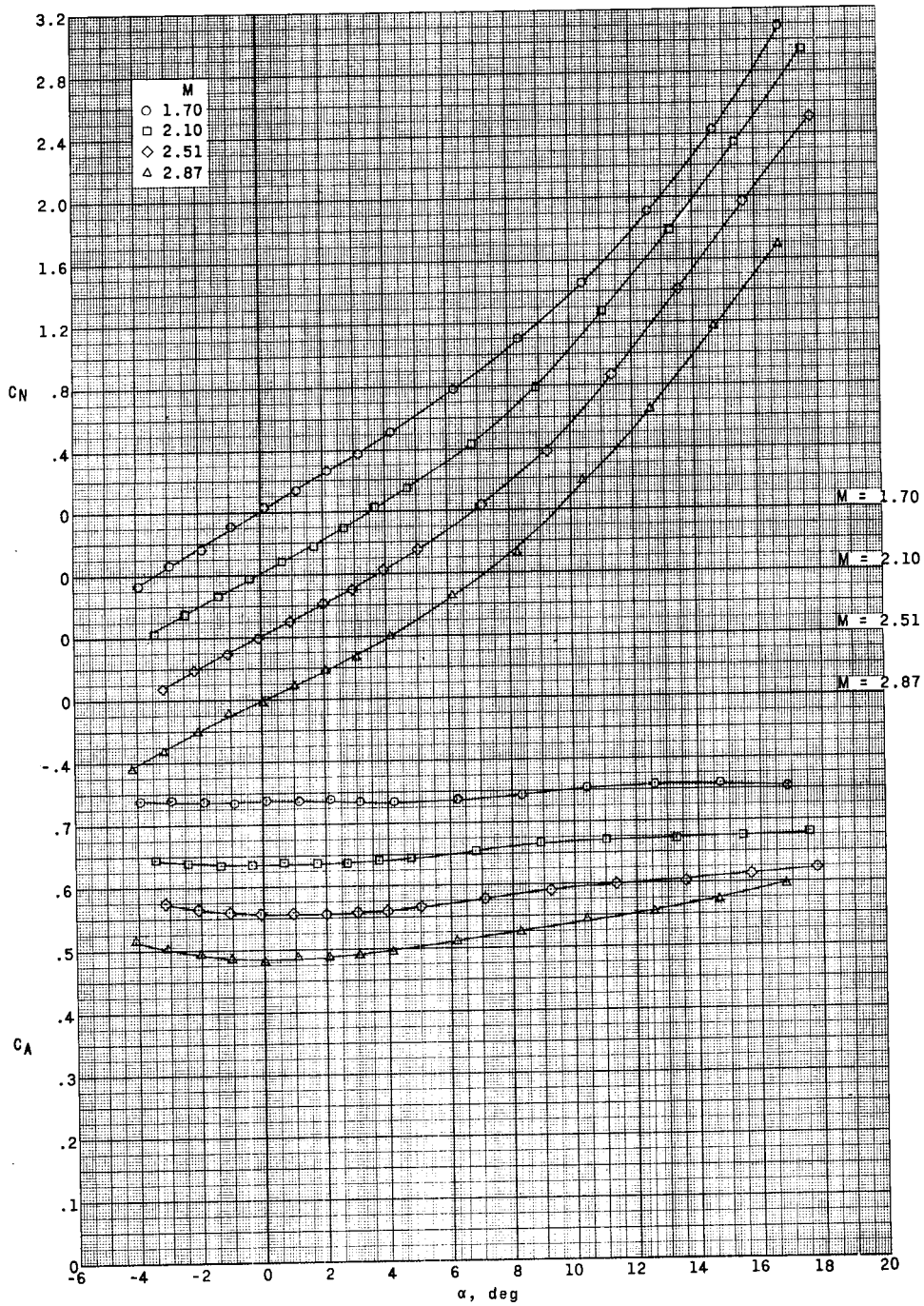
Figure 8.- Continued.

CONFIDENTIAL

03172201030

42

CONFIDENTIAL



(b) 4-foot UPWT.

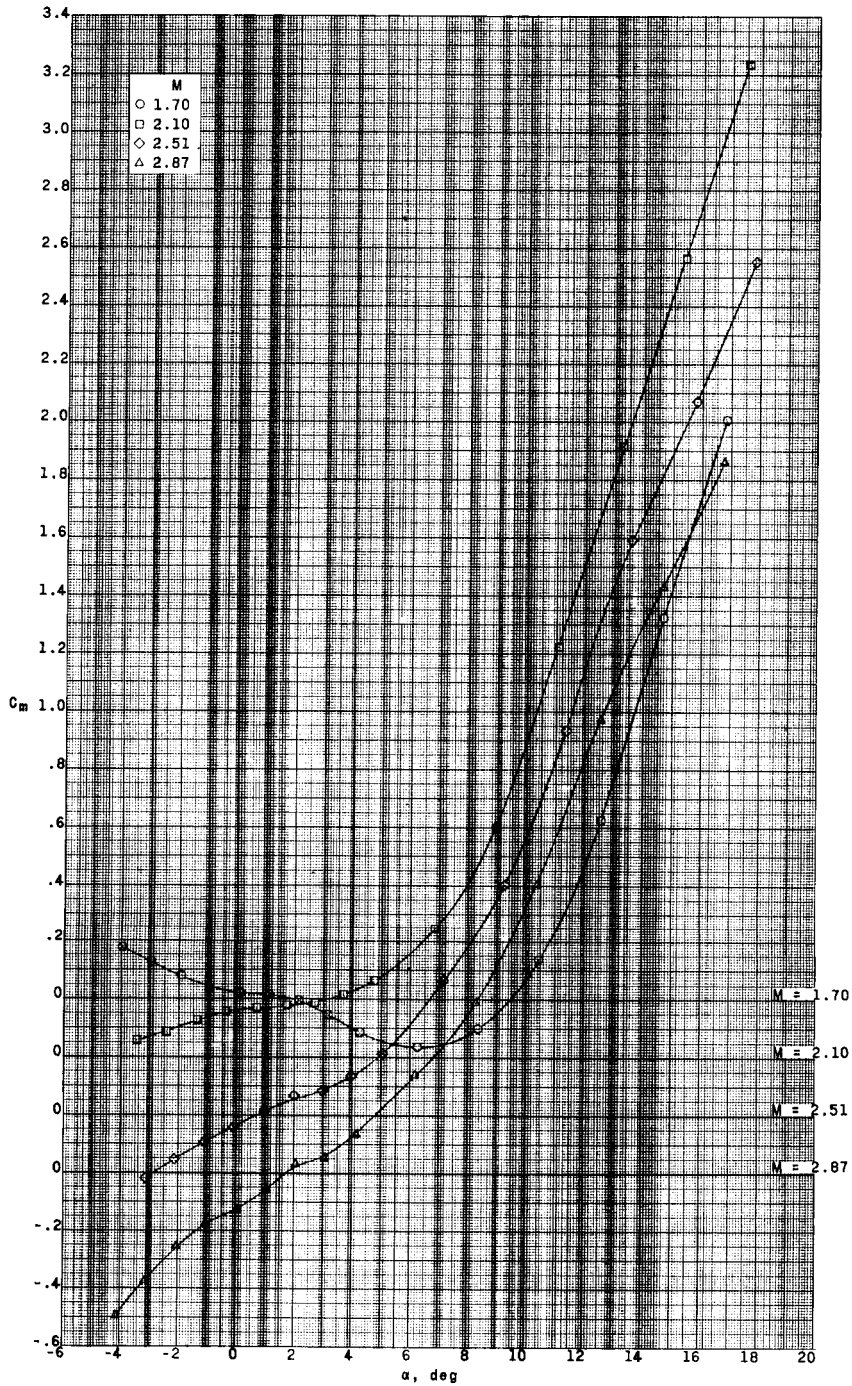
Figure 8.- Continued.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

43



(b) Concluded.

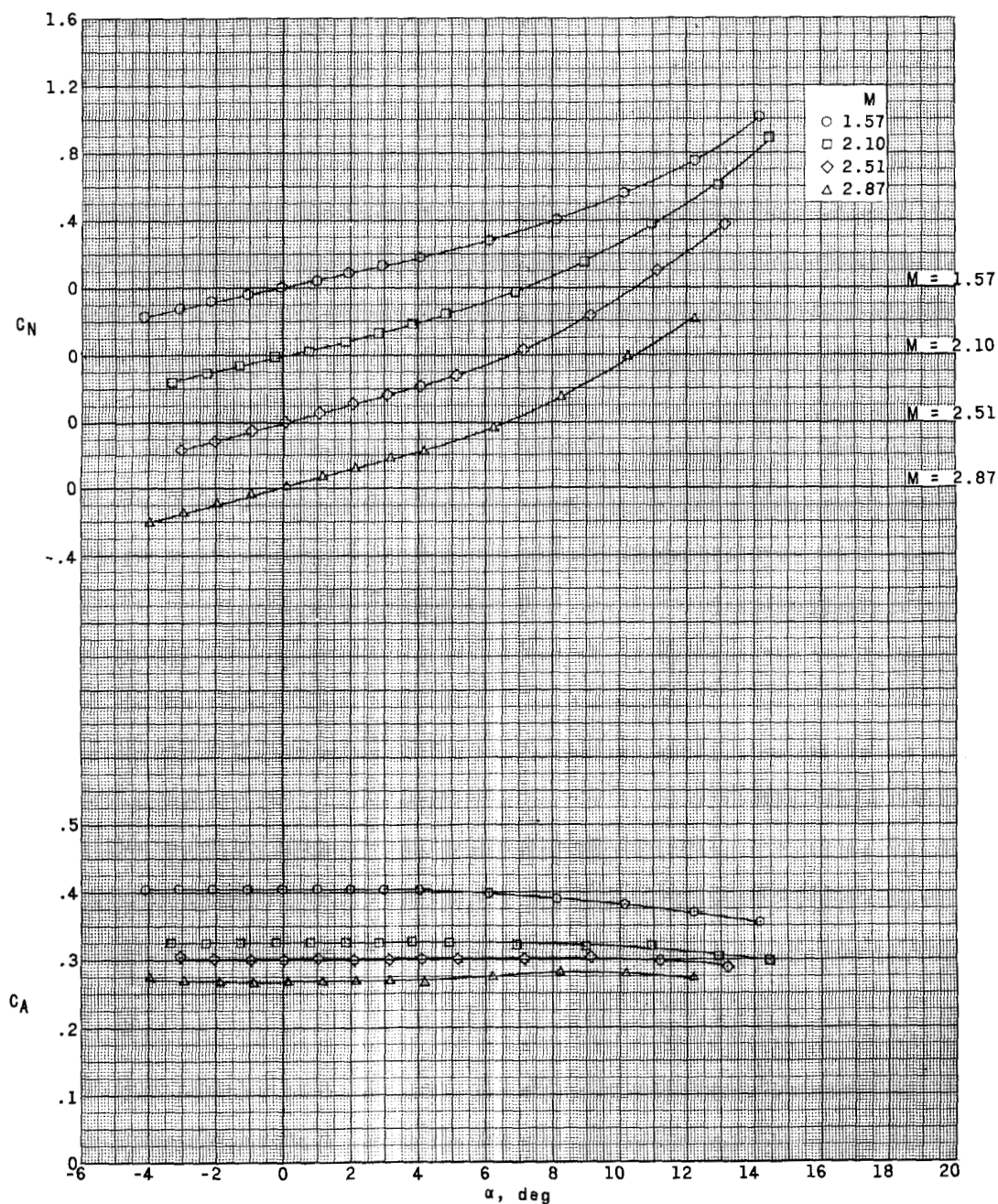
Figure 8.- Concluded.

CONFIDENTIAL

037126J030

44

CONFIDENTIAL



(a) 4-foot UPWT.

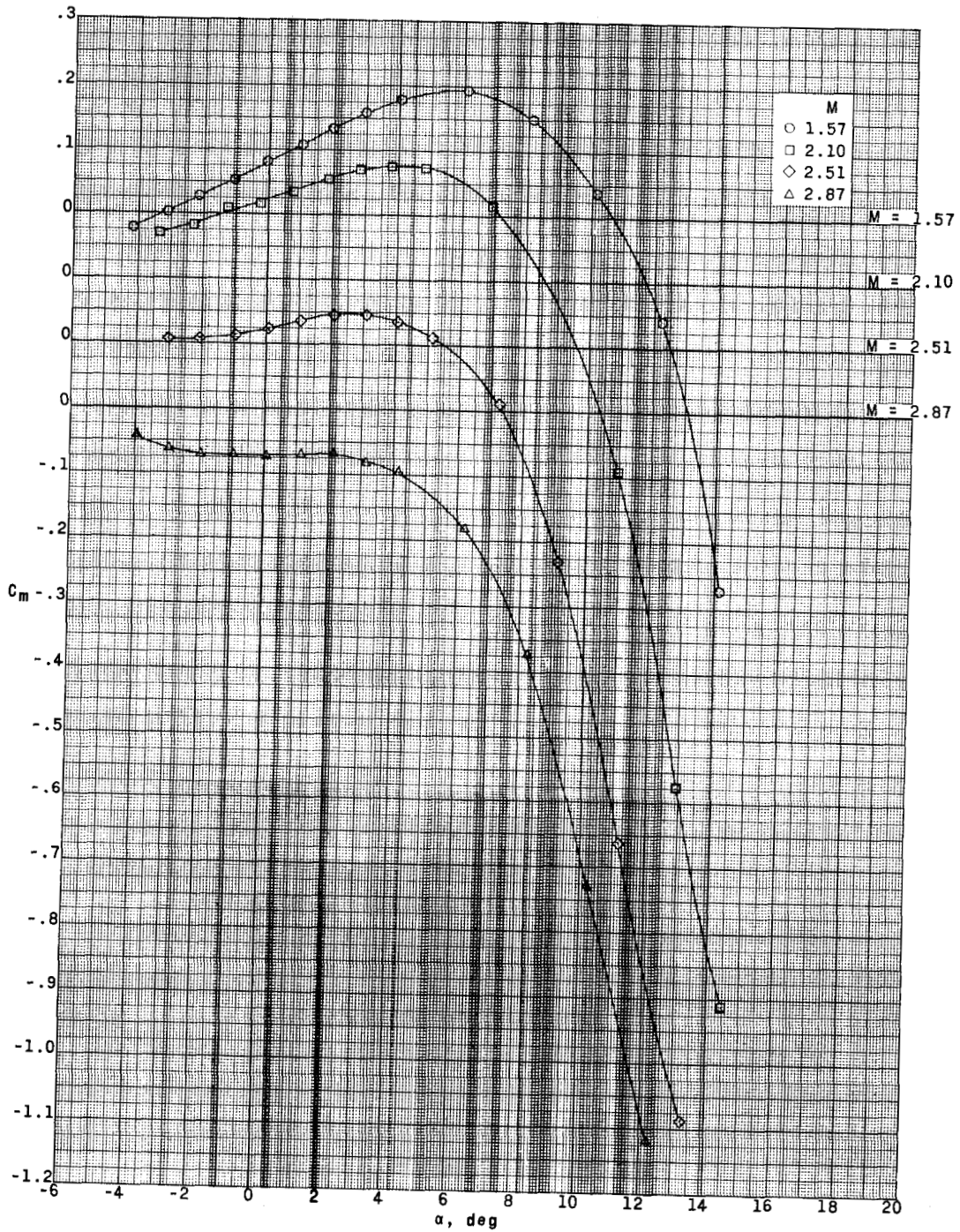
Figure 9.- Aerodynamic characteristics of Jupiter-Mercury configuration.  
Moment reference center at station 223.7.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

45

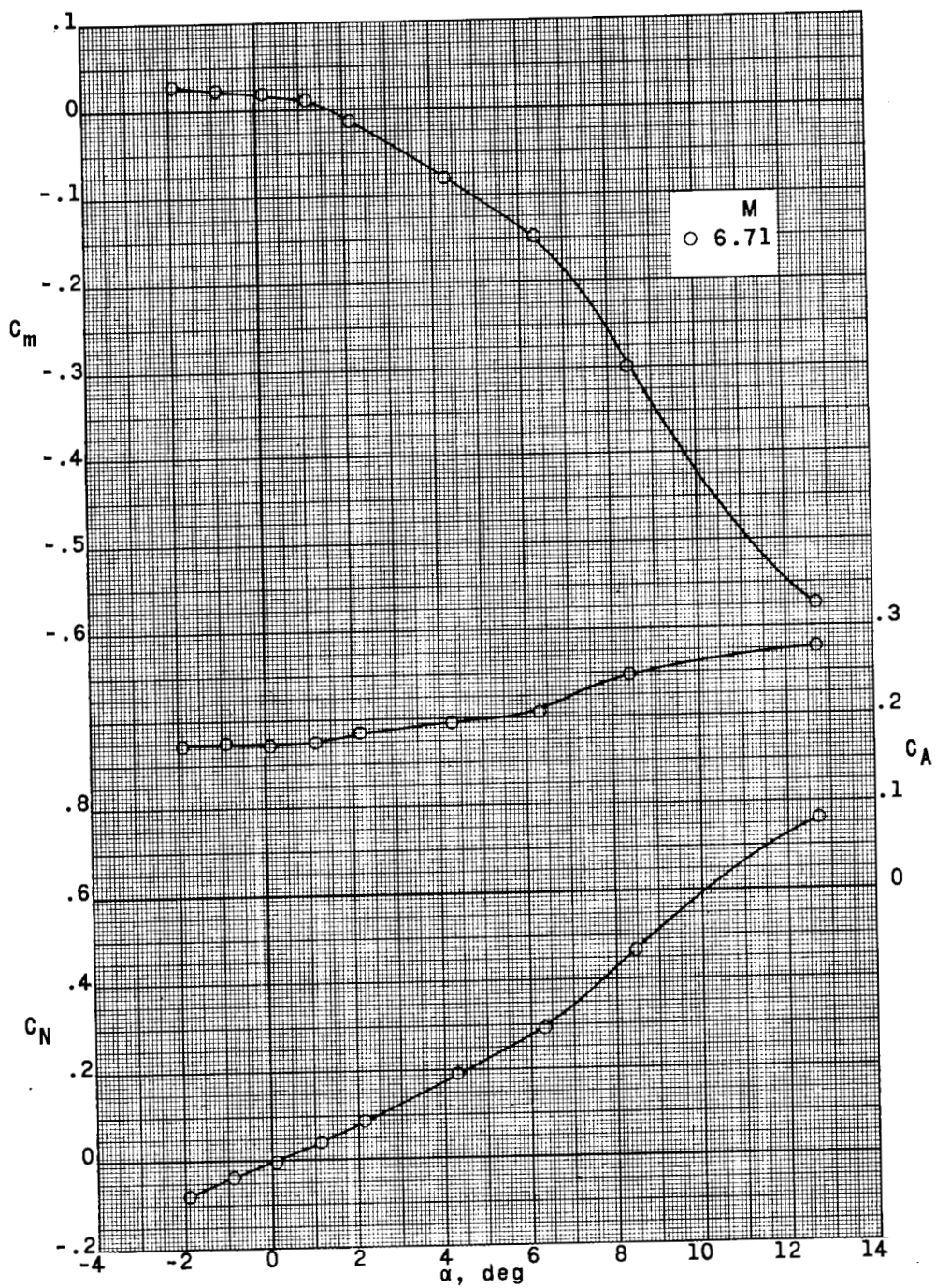


(a) Concluded.

Figure 9.- Continued.

CONFIDENTIAL

CONFIDENTIAL



(b) 11-inch HT.

Figure 9.- Concluded.

CONFIDENTIAL

DECLASSIFIED

CONFIDENTIAL

47

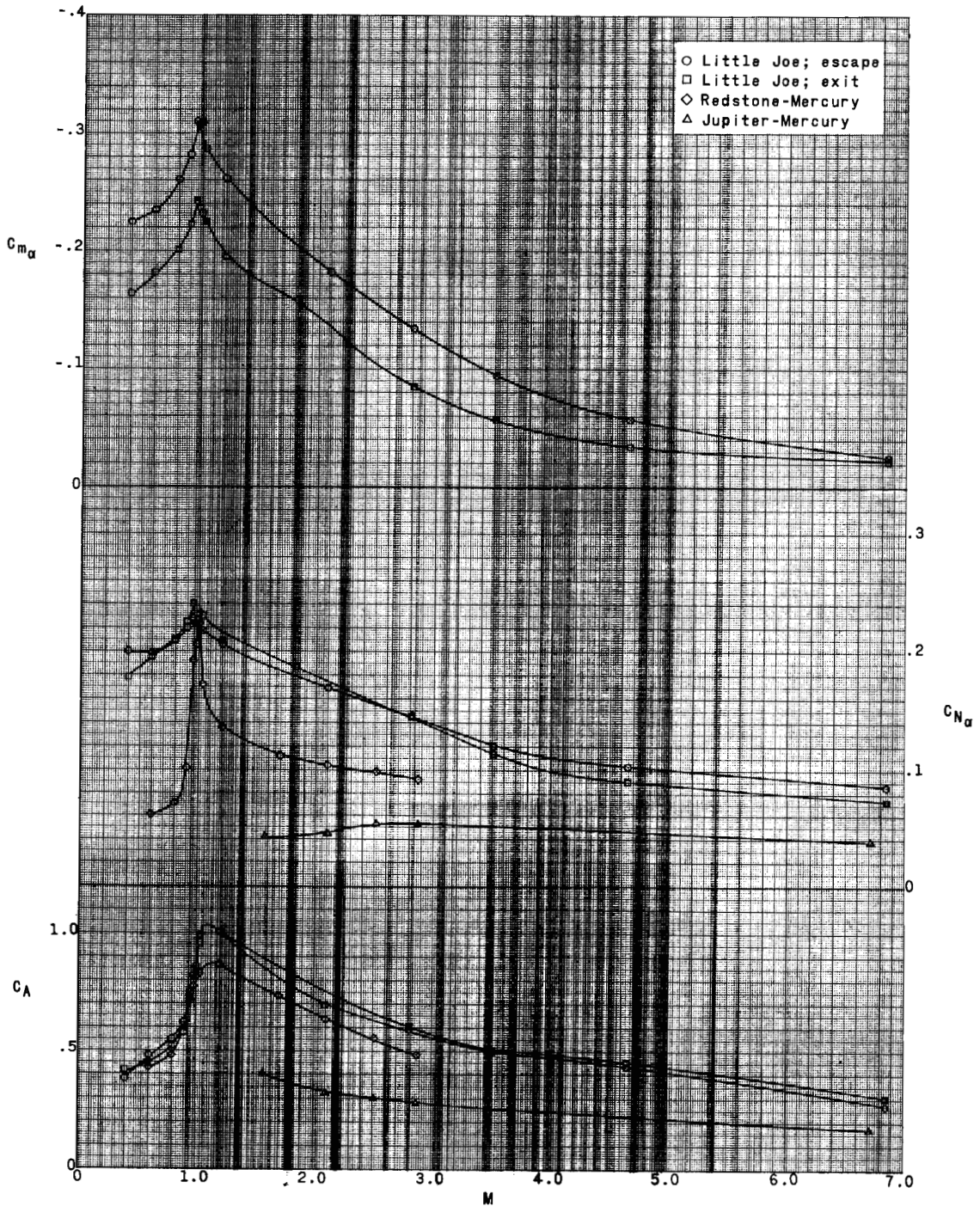


Figure 10.- Summary of longitudinal characteristics;  $\alpha \approx 0^\circ$ . Moments taken about reference centers of figure 2.

CONFIDENTIAL

03710201030

48

CONFIDENTIAL

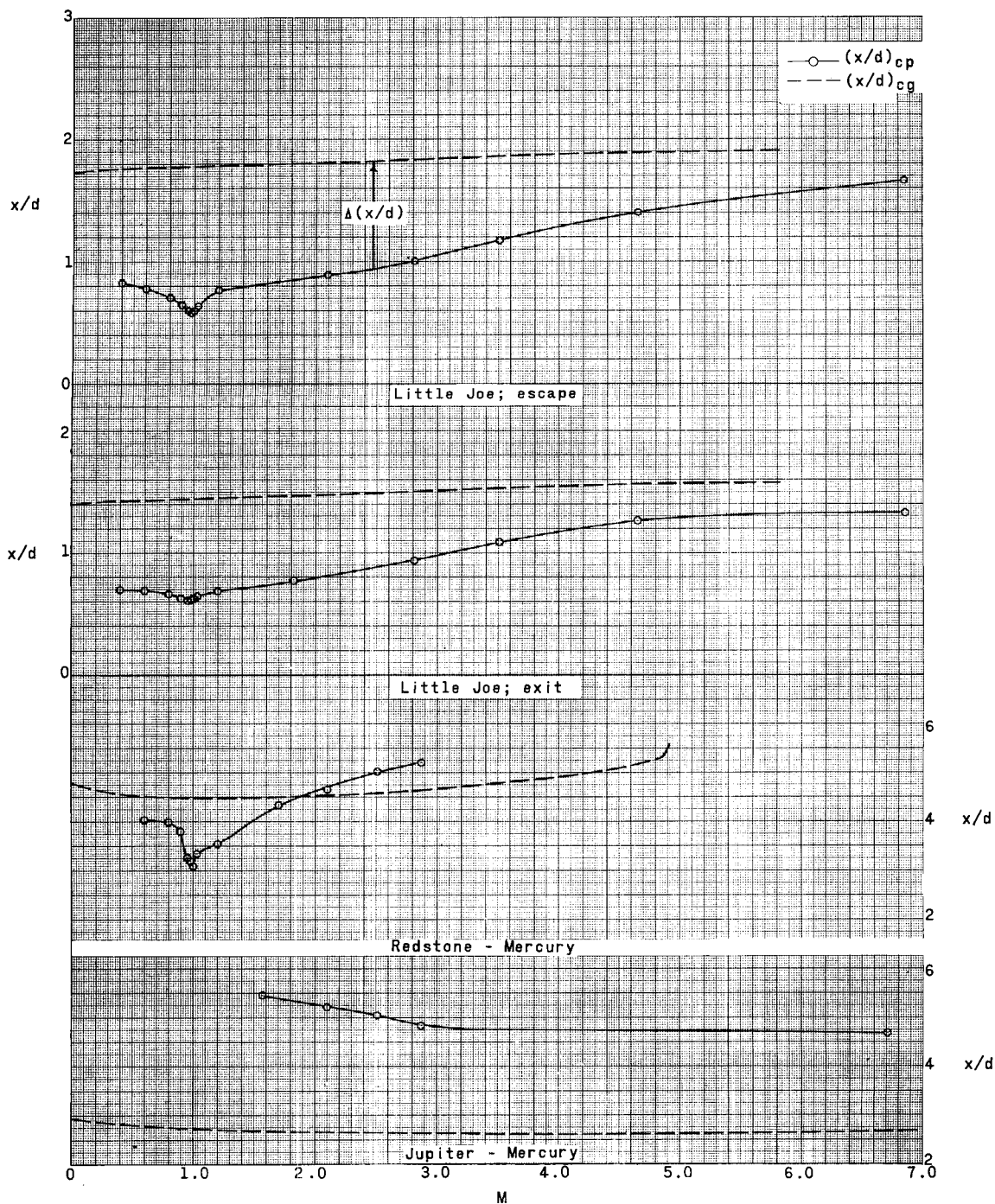


Figure 11.- Summary of effective static margins;  $\alpha \approx 0^\circ$ .

CONFIDENTIAL

NASA - Langley Field, Va. L-910